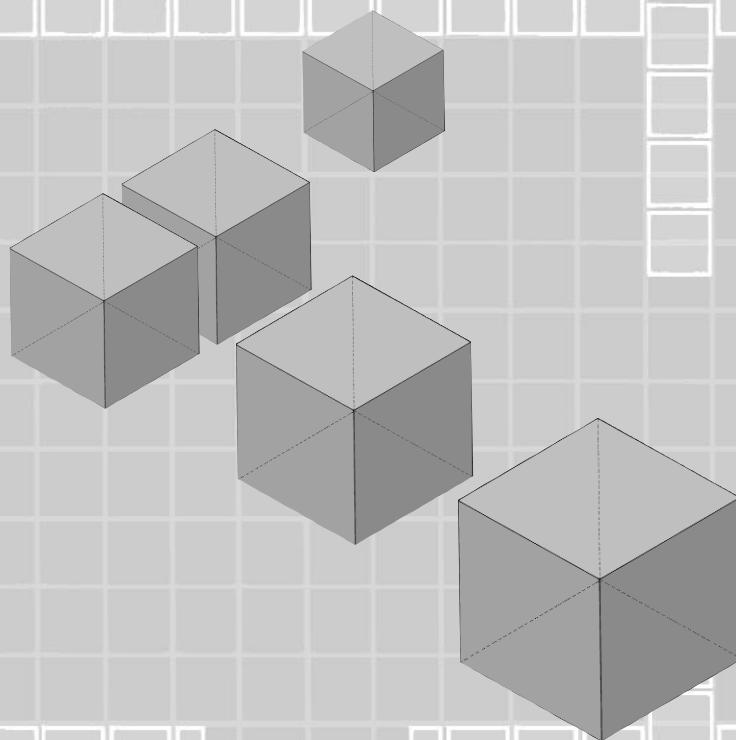
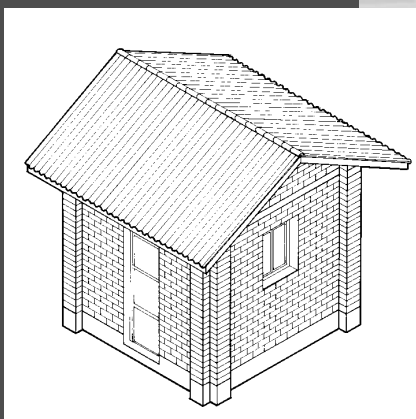
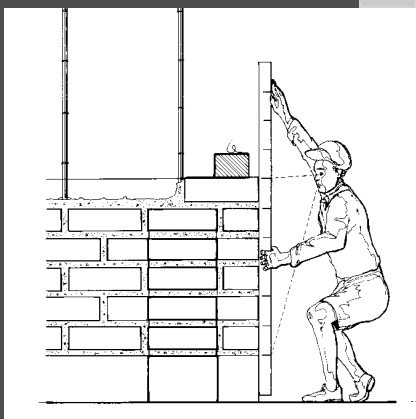




ADOBE

Anti-seismic construction handbook

Wilfredo Carazas Aedo



MISEREOR



PRELUDE

Adobe has been present throughout the history of the world as a building tool, from the dawn of civilisation to the present day. Man learnt to build his first dwellings with earth. Throughout this period major civilisations developed where earth was and – still is - part of a highly intelligent building culture.

We also know that adobe has had to endure the violence of nature, especially earthquakes which caused considerable destruction and consequently left the population homeless. This material requires greater attention and a certain amount of knowledge about earthquakes in order to confront this natural phenomenon more effectively.

This has drawn the attention of many researchers and scientists who have proposed interesting and effective alternatives, leading to anti-seismic building regulations and standards which in practice have proved to be efficient.

The aim of this handbook is to assist engineers and the population at large in repairing houses correctly.

The handbook is divided into three main parts:

- 1 - Earthquakes:** how they origin, how they affect houses and how is the anti-seismic houses.
- 2 -The method:** the steps to follow to make resistant adobe.
- 3 -Anti-seismic construction:** design, implementation and steps to follow.

Furthermore, an appendix is included with details of the “**La Semilla**” and a farmhouse.

We have structured the handbook in this way so as to give the builder or dweller a clearer idea of the reasons for the dimensions, shape and building technique, which although initially may have certain limits, also provide a more earthquake resistant house.

A house is only considered anti-seismic once it has satisfied all the required parameters: **correct design, quality of the ground, quality of construction and building materials.**

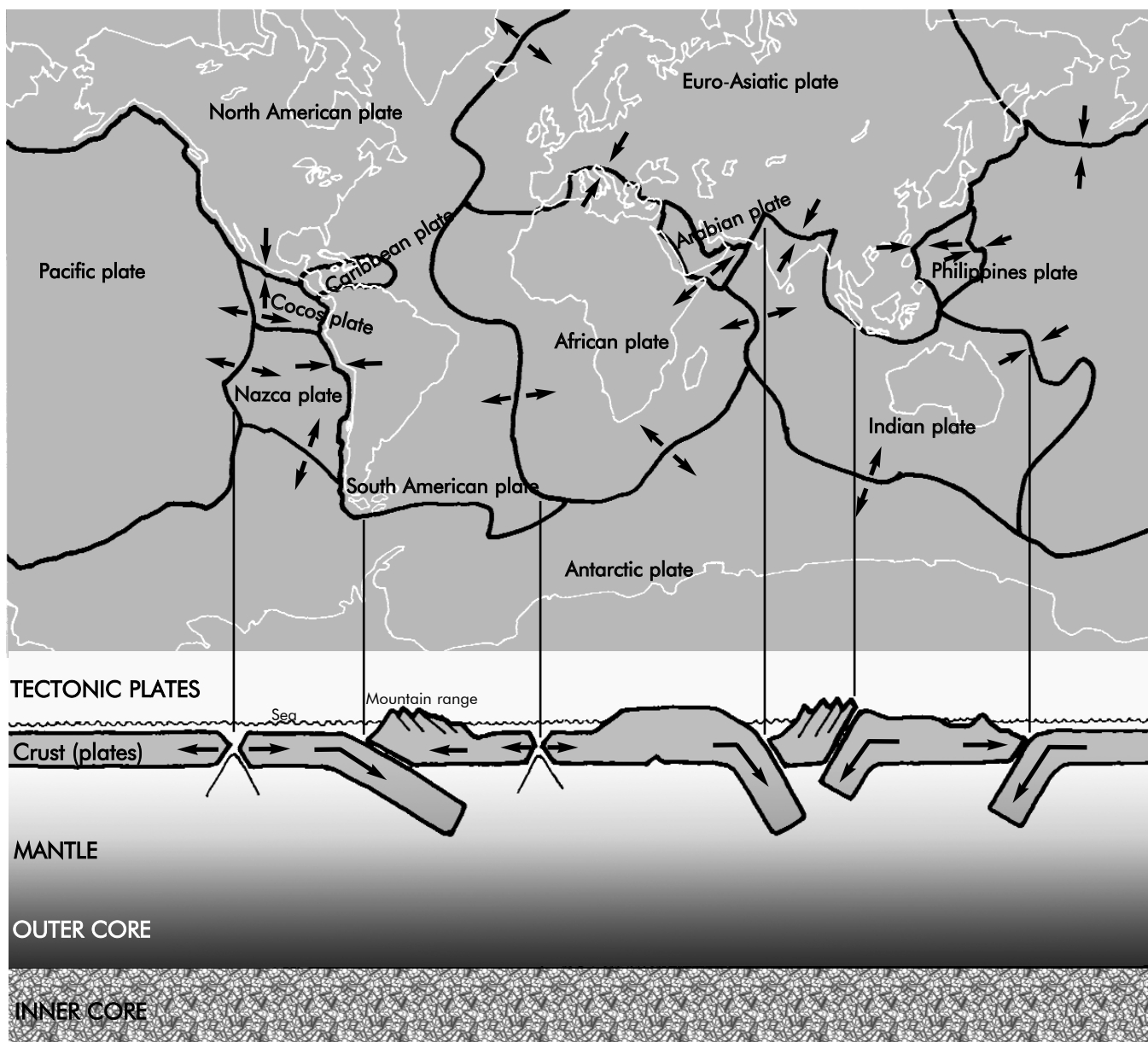
“ADOBE: ANTI-SEISMIC CONSTRUCTION HANDBOOK”

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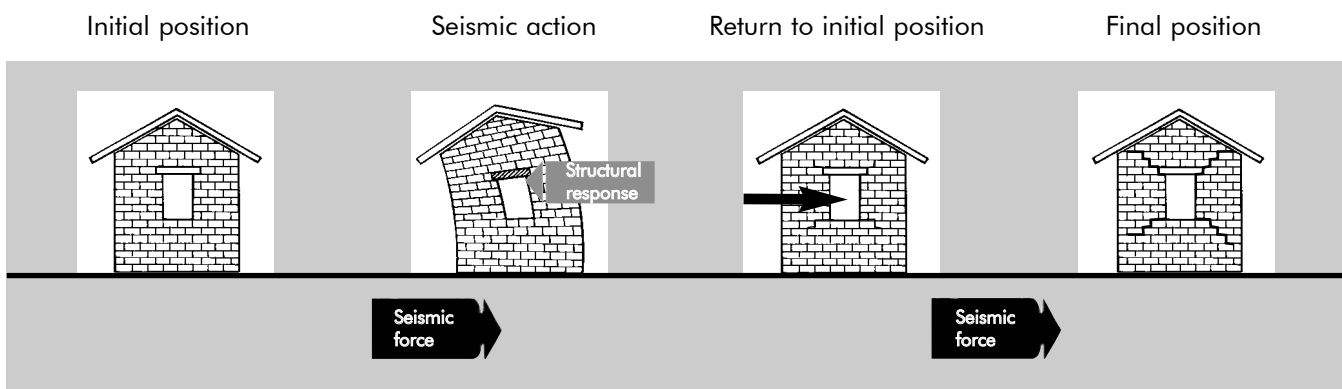
THE ORIGIN OF EARTHQUAKES

The earth dates back approximately 4.5 million years. Since this period the internal mass of the earth has been constantly moving, transforming the continents. The globe has a radius of 6,400 km and consists of several successive layers. If we look at a cross-section, we will see: the nucleus, the mantle and the earth's crust.



There are several plates on the earth's crust, they differ in the way they behave: some move apart, others collide and others simply move one on top of another. These plates move slowly at an average speed of 1 cm to 15 cm per year. These movements produce deformations which lead to forces which exceed the resistance of materials and free accumulated energy. This is what generates **EARTHQUAKES**.

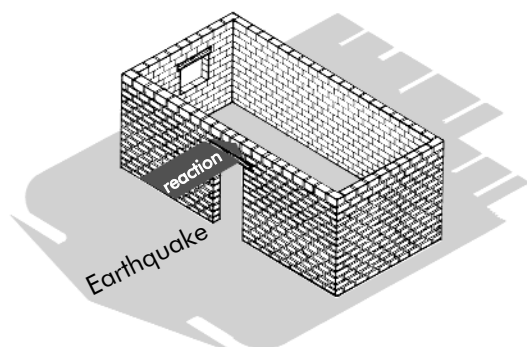
SEISMIC PRINCIPLES:



FORCES SISMIQUES

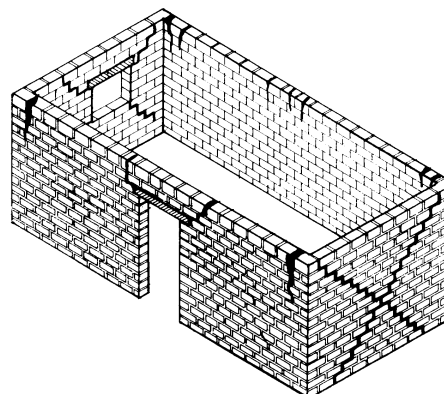
When an earthquake occurs, a house is shaken by vertically oscillating movements, horizontal forces and torsion, all at the same time. The house will respond according to its characteristics: its shape and type of material. To understand this better we shall separate these three movements.

ACTION

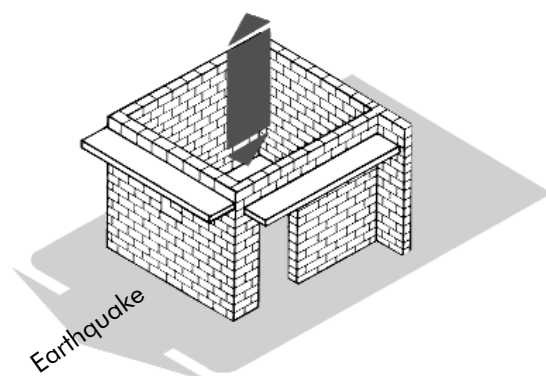


EFFECTS

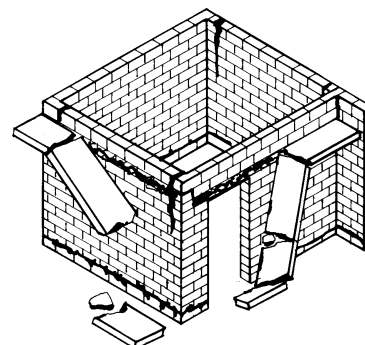
Horizontal forces



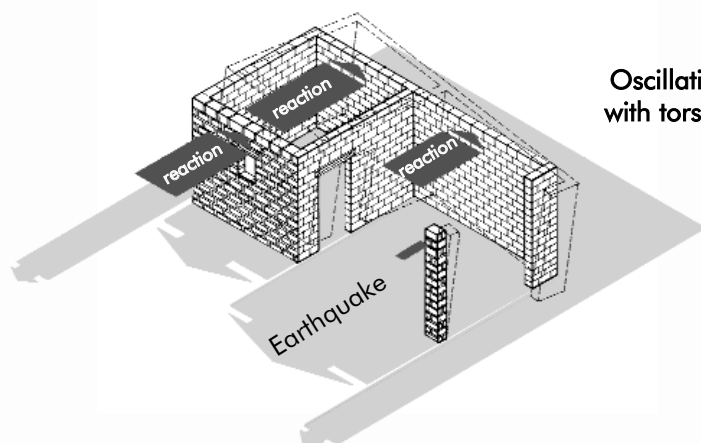
Horizontal forces: Seismic waves make the ground vibrate creating horizontal forces in the construction which is shaken, rocked, deformed and demolished. This bending and tearing of the wall loosen it and make it slide concerning to the foundation.



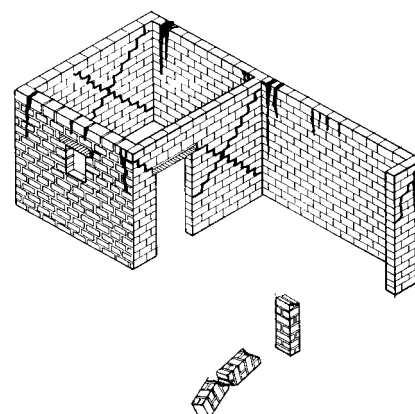
Vertical oscillation



This is another type of oscillation which occurs during an earthquake. Its effects are minimum, only heavy parts are affected, such as arches, columns, roof structures, and also projecting parts like balconies and eaves, etc.



Oscillation with torsion



Finally, oscillation with torsion is the result of horizontal movements of the ground together with lateral forces. The effects of torsion are more or less important depending on the shape of the construction, for example irregular shaped houses where the centre of gravity does not coincide with the centre of rigidity will be more exposed to damage.

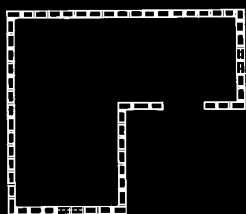
THE EFFECTS OF AN EARTHQUAKE ON A HOUSE

To face an earthquake, a house must satisfy minimum technical requirements, correctly using materials and optimizing the design. For example, some features should be avoided, such as: irregular shaped houses in terms of size and height.

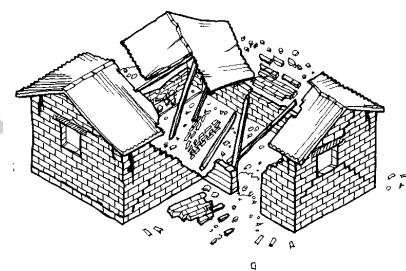
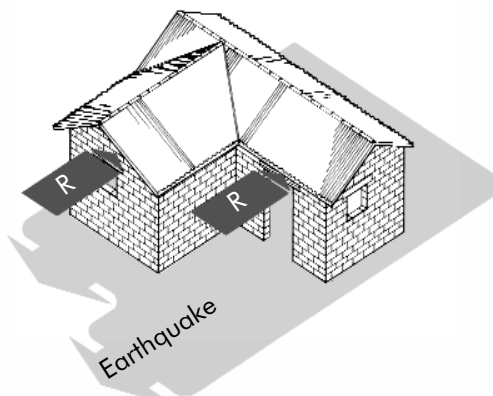
Type of wall

Movement

Effect



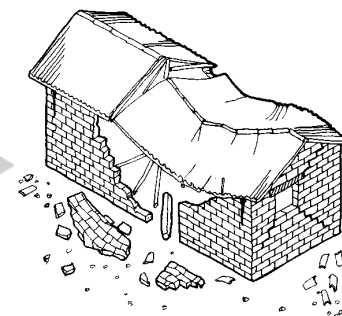
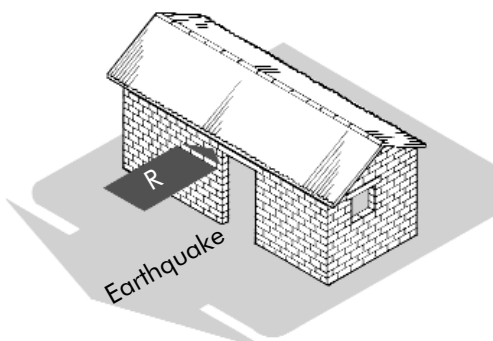
L-shaped construction



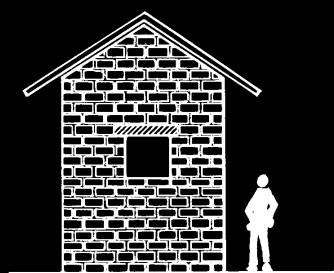
This house has walls with different dimensions which in an earthquake will behave deficiently making the house collapse more quickly.



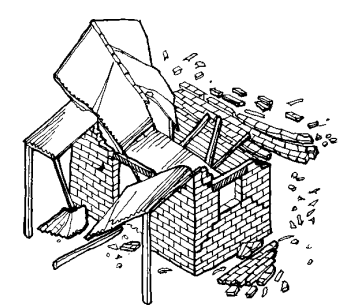
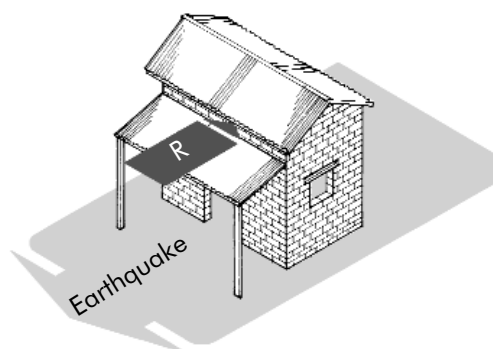
Rectangular construction



Its wide walls without intermediate supporting walls and with weak corners are less resistant in an earthquake making it collapse.



High construction



Due to its high thin walls it is more flexible and less resistant to earthquakes.

Other examples of features to be avoided include:

- "T" and "C" shaped buildings,
- Storey buildings.
- Ceiling panel beams located directly above the wall.
- The use of inside walls as support for the roof.
- Constructions built on slopes,
- Wide spaces between the walls.
- Columns, arches, domes and vaults.

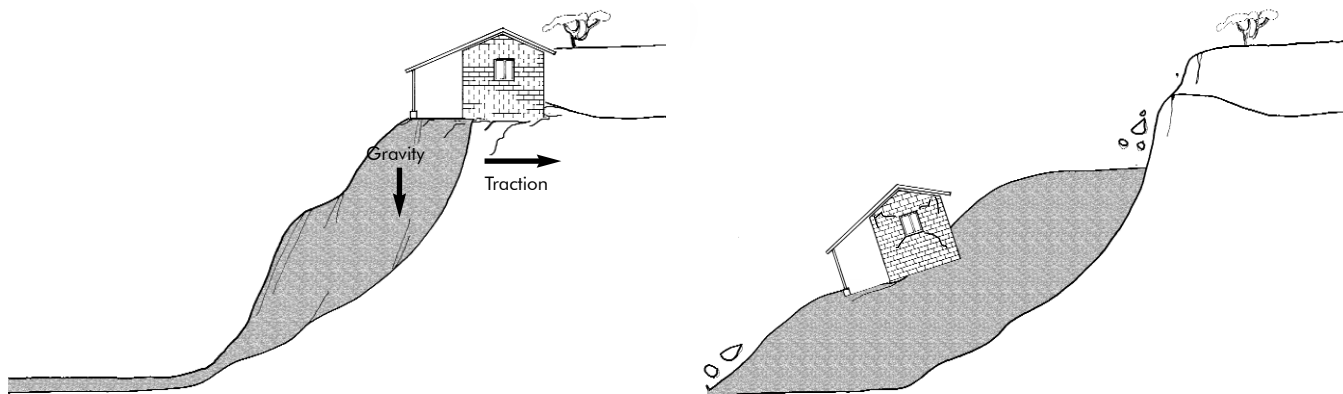
SELECTING LAND FOR BUILDING

Building a house requires a suitable decision with regard to choosing the land. Several basic criteria for recognition are needed: flat and dry land with a hard surface is appropriate. It is better to avoid unsuitable areas for building: reservoirs, cliffs, areas close to rivers, on former mines, on landfill sites, etc. If a house is built correctly but on unsuitable ground, the result is the same as a bad construction.

Position

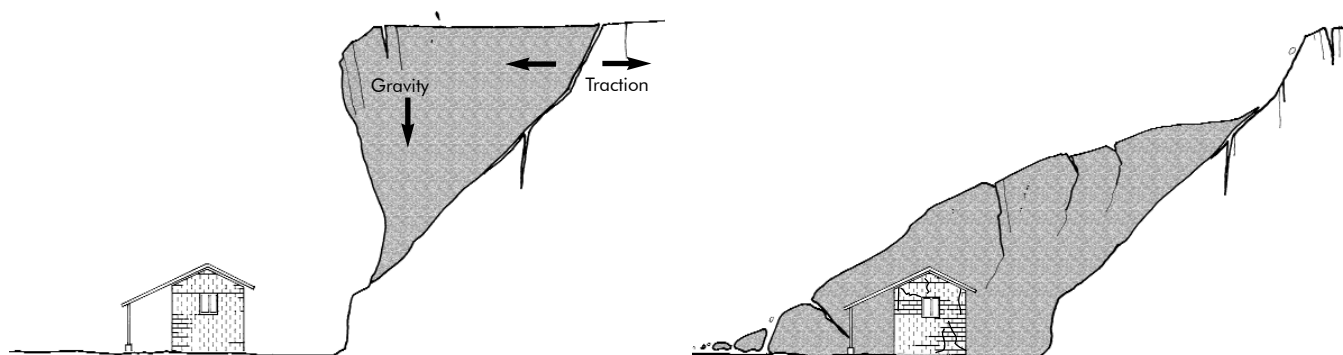
Effects

HOUSES ON CLIFFS



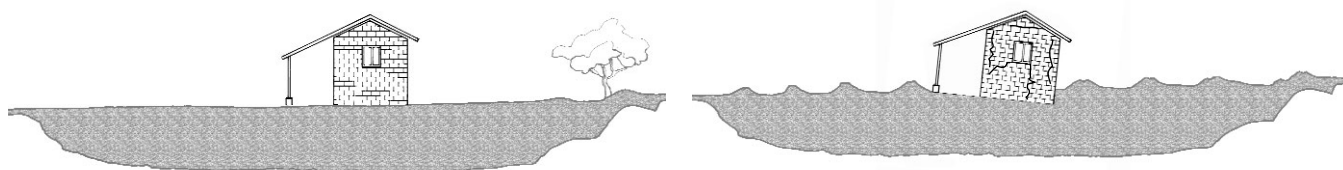
Cliffs made of soft or crumbly ground, clay loam, deposits of materials, etc. are not suitable for building houses.

HOUSES IN LOW-LYING AREAS



It is not advisable to build a house at the bottom of a cliff with a perpendicular face and with large crevices since these may worsen the effect of an earthquake.

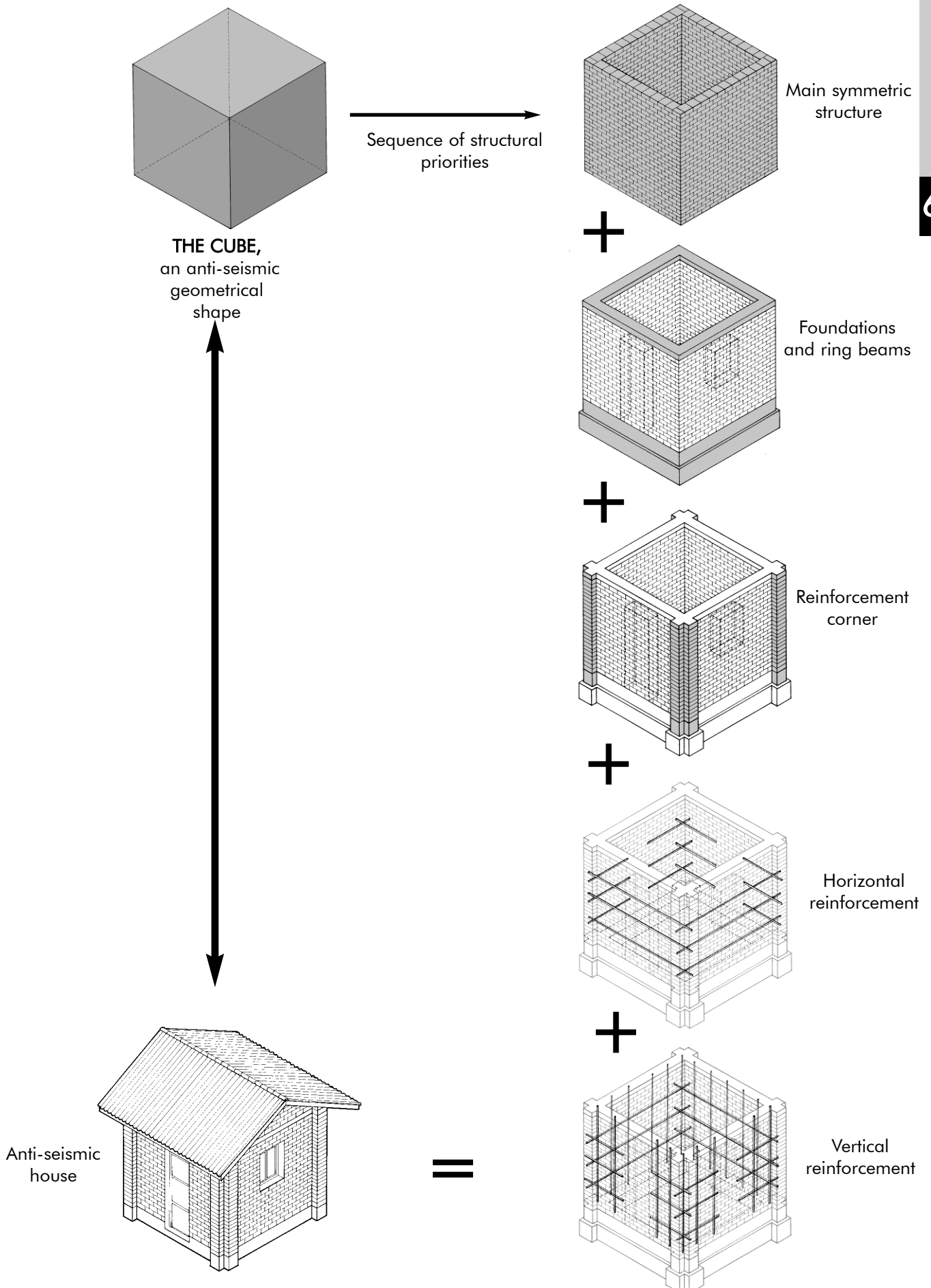
HOUSES ON SOFT GROUND



In the event of an earthquake the presence of water provokes a "liquefaction" effect leading to a total collapse of the ground ruining the construction.

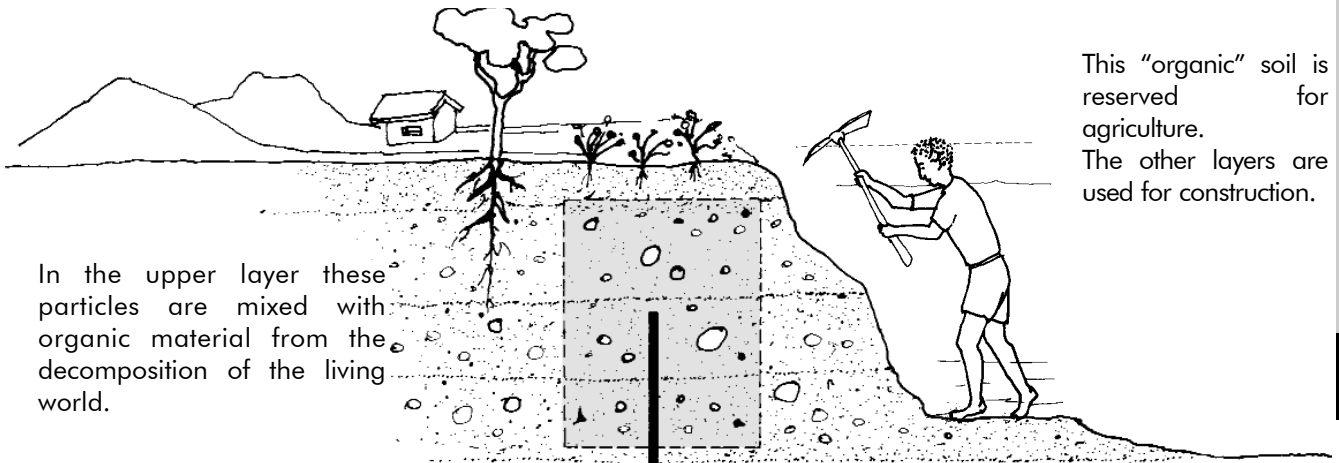
THE ANTI-SEISMIC HOUSE

An anti-seismic house is a house built using a series of appropriate building and design techniques so as to resist an earthquake. The cube shaped house is the basic principle which guarantees anti-seismic resistance, from which we shall develop the necessary technical structural steps.



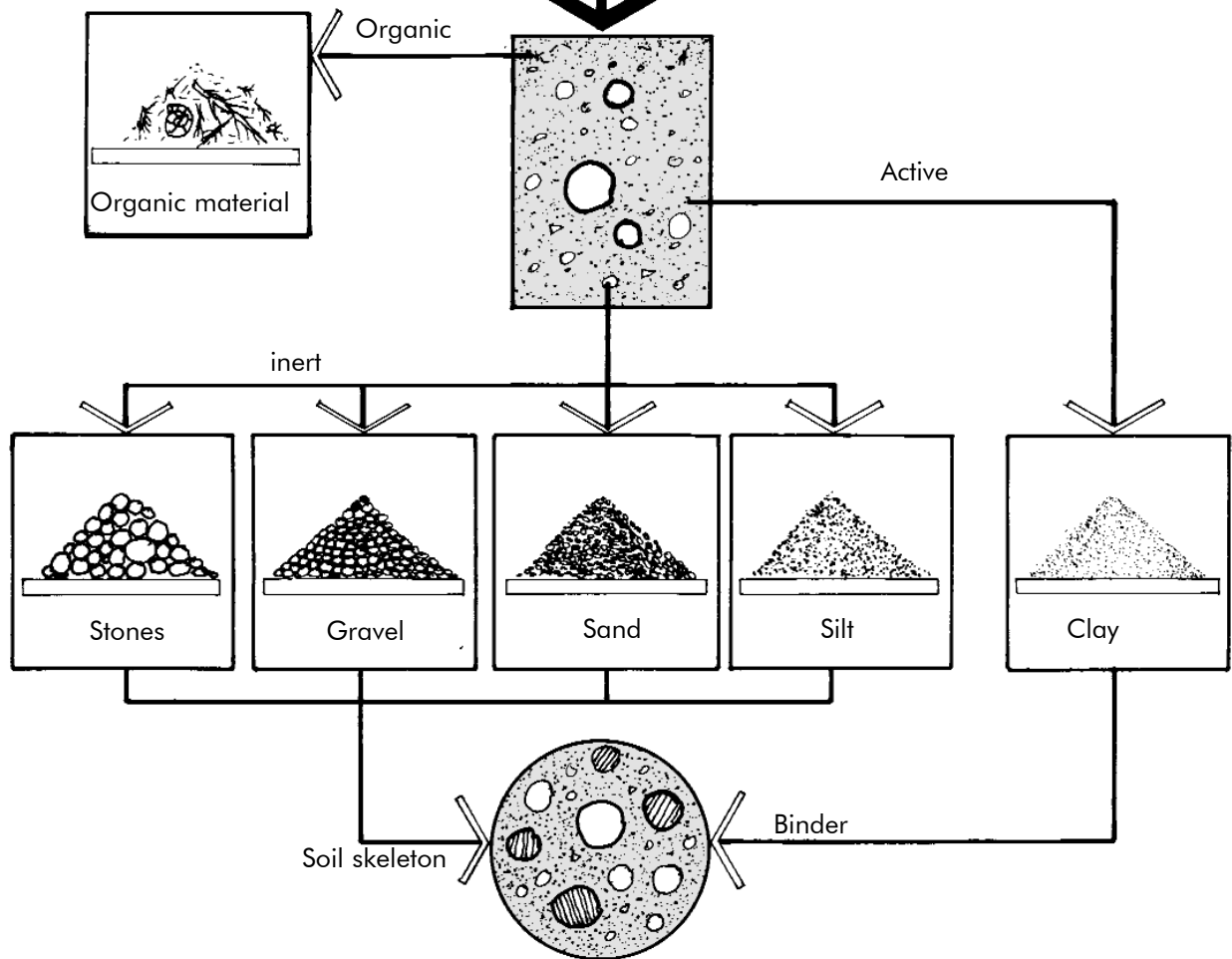
EARTH AS A BUILDING MATERIAL

ORIGIN : Earth comes from the mechanical and chemical erosion of the parent rock. This rock disintegrates into mineral particles with varying dimensions from pebbles to clayey dust.

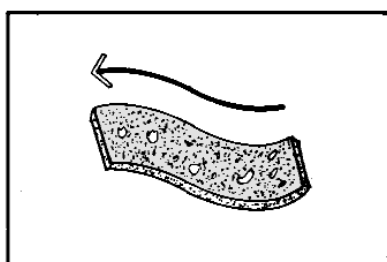


This "organic" soil is reserved for agriculture. The other layers are used for construction.

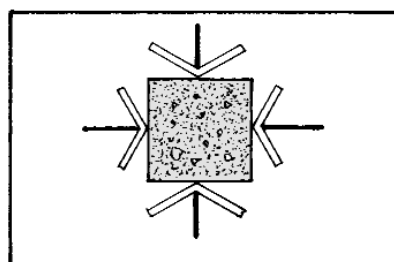
In the upper layer these particles are mixed with organic material from the decomposition of the living world.



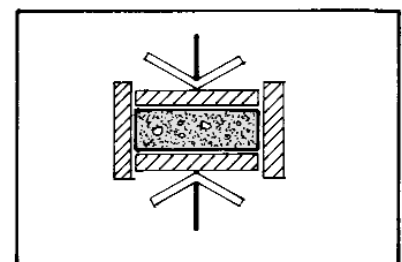
PROPERTIES OF EARTH



Plasticity



Cohesiveness



Compactability

There are several different types of earth according to the quantities of the following components:
GRAVELLY EARTH – SANDY EARTH – SILTY EARTH – CLAYEY EARTH

HYDRIC STATE, COHESION & STABILISING

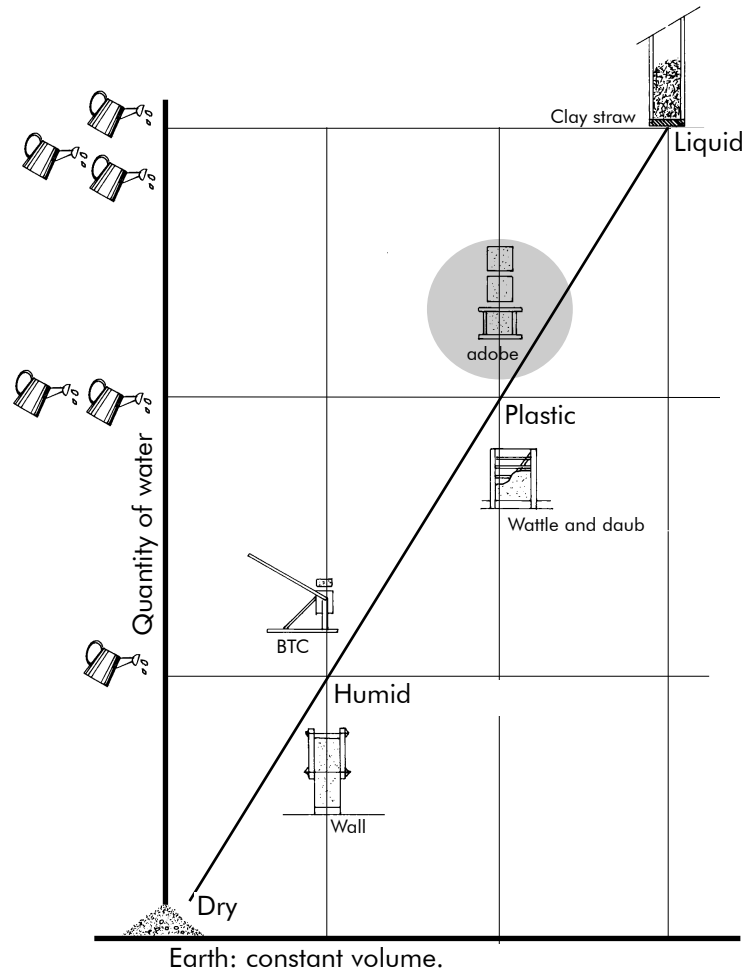
HYDRIC ACTION

As the earth absorbs water (between 20% and 30% according to the type of ground), its state changes.

There are 4 basic states:

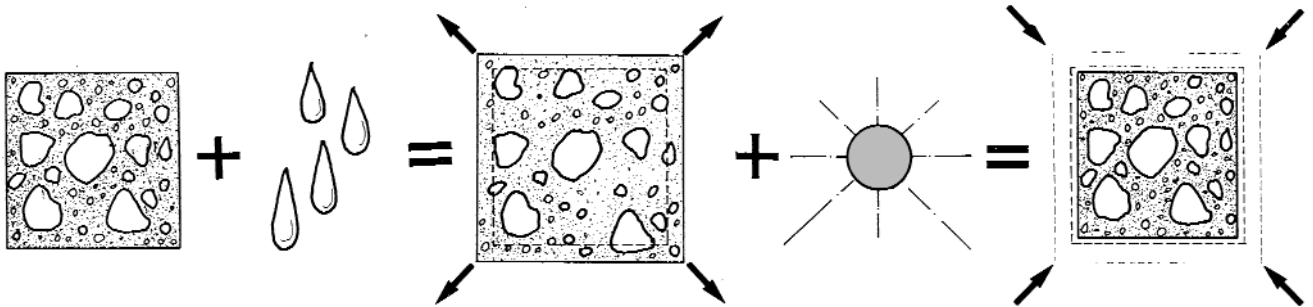
DRY – HUMID - PLASTIC - LIQUID::

Adobe is produced in its PLASTIC state. This humid state enables us to shape the earth using a mould and keep its shape after demoulding until it returns to its dry state.



COHESION PROPERTIES

To prepare the adobe the COHESION property is used which works in two phases:



Phase 1: The earth absorbs water and the clay begins to inflate. This is a long process which requires time.

Phase 2: The earth dries, the volume of the clay decreases attracting to it the other components which are completely dry and tied.

If there are no gaps between the grains, the compression resistance of a dry adobe reaches approximably 3Mpa

STABILISING

When the earth is clayey there is an excessive risk of cracking once dry.

It can be corrected by:

- increasing the amount of sand so as to reduce cohesion,
- mixing with straw with the aim of limiting the size of cracks.



ANALYSIS OF THE SOIL

AIM: Through simple field tests check whether the ground is suitable for producing adobe bricks. These tests show us the features of the ground. To check its components or granulometry: handling – smell, its plasticity: the “cigar” its cohesion: the “patch”. The results of these tests show us the quality of the earth.

HANDLING – SMELL



-With water, our senses enable us to identify the main components of the earth.

ORGANIC earth – Gives off a smell.

SANDY earth - Rough, crumbly, not very sticky

SILTY earth - Fine, easy to reduce to dust, sticky.

CLAYEY earth – Difficult to break, slow to dissolve in water, very sticky and fine.

CONVENIENCE:

The best is to find both sandy and clayey earth.

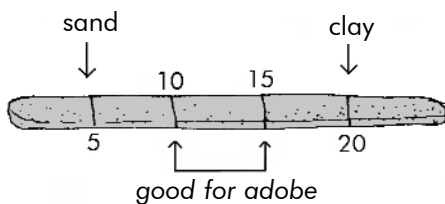
Take care with silty earth because once dry it does not resist water.

THE “CIGAR”



Less than 5 cm. **TOO SANDY**

More than 20 cm. **TOO CLAYEY**

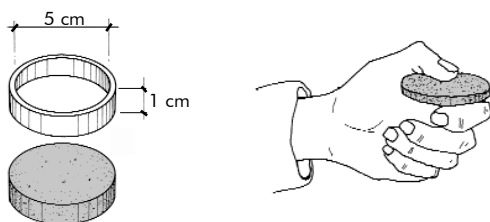


- Remove the gravel from the sample.
- Moisten, mix and allow the earth to settle for half an hour until the clay can react with the water.
- The earth should not stick your hands.
- On a board, mould a cigar with a 3 cm diameter and 20 cm long.
- Slowly push the cigar onto one edge.
- Measure the length of the piece which comes away.
- Carry out this operation 3 times then calculate the average length .

CONVENIENCE:

Between 7 and 15 cm of good earth.

THE PATCH



Re-use the earth from the previous test in its plastic state. Mould 2 patches using a plastic tube or similar object.

After drying:

- Observe any retraction that occurred.
- Assess the resistance of the earth by breaking and crushing between the thumb and the index finger

- No retraction, easy to convert to dust:

SANDY earth



- Retraction, easy to convert into dust:

SILTY earth



- Significant retraction, very difficult to reduce to dust:

CLAYEY earth



CONVENIENCE:

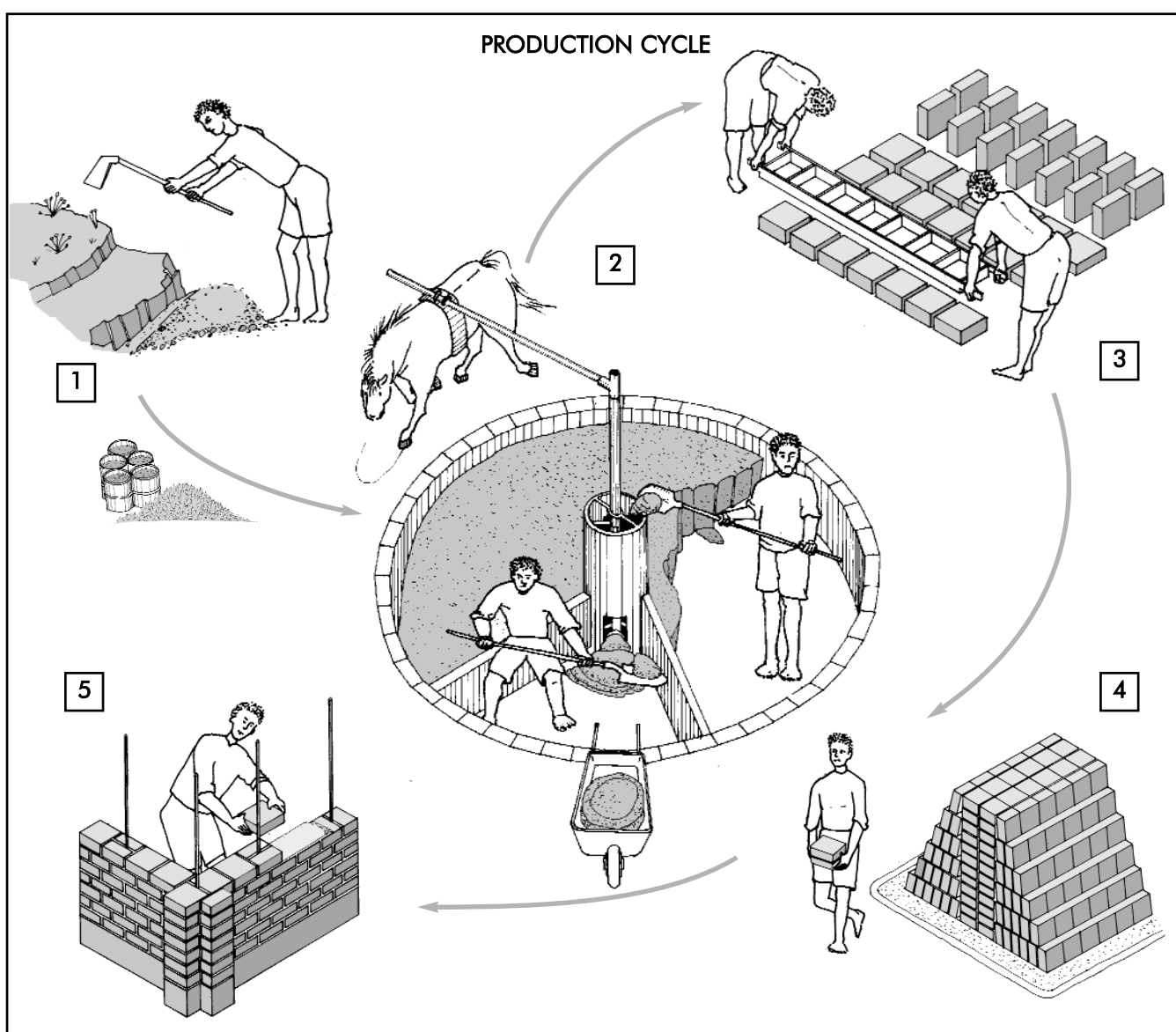
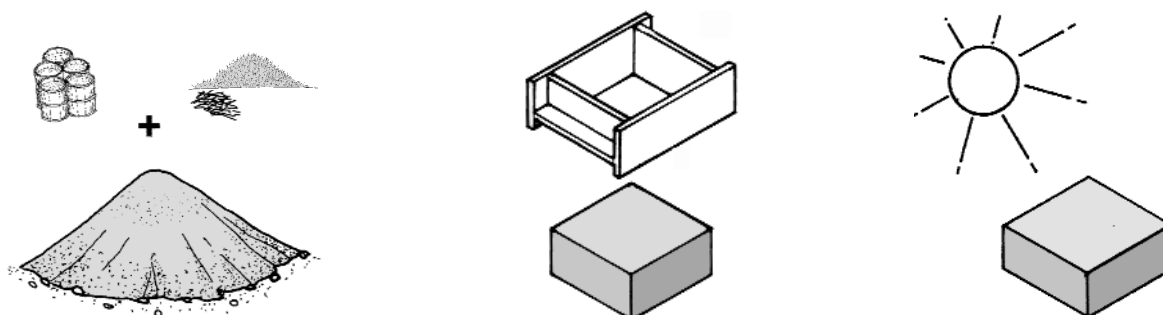
Less than 1 mm retraction, difficult to reduce to dust: Good earth.

SUGGESTION.

It is best to mould the adobe then analyse its behaviour after drying (appearance, cracks, resistance). If you do not have much time, field tests will help you to select the best earth.

INTRODUCTION

Adobe is a mixture of suitable earth, water and straw, prepared and moulded in its plastic state then dried in the sun.



ADVANTAGES:

- Locally available raw material.
- No costly production equipment required.
- Accessible to everyone.
- Fuel useless.

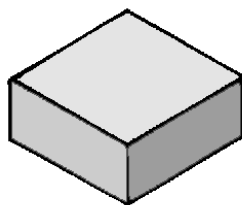
DISADVANTAGES:

- Consumes a large amount of water.
- Wide drying area needed.
- Drying time depends on the climate.
- Low resistance to water.

ANTI-SEISMIC ADOBE

Square adobe is in line with anti-seismic thinking: its shape adapts easily to the design of the house and the preparation is more advantageous. It is proven that its mechanical resistance is greater than rectangular adobe. Its composition will also influence its quality and behaviour in the face of an earthquake: suitable soil, dry straw and the necessary water.

SQUARE ADOBE



=

CLAYEY EARTH



Important:

The adobe must have the following dimensions: 30x30x10 cm.

If the earth is not optimum you will need to mix until you achieve a quality adobe

Important:

The earth must be free from organic material and dry, otherwise determine the initial percentage of humidity.

Use one volume of this clayey earth.

+

SANDY EARTH



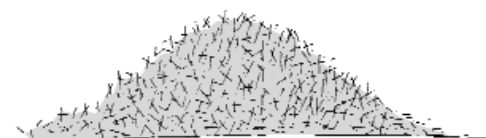
Important:

Use three volumes of this sandy earth.

If the earth is not suitable mix it with another type, eg. for clayey earth use sandy earth and vice versa, mixing in the right proportions. Generally three portions of sandy earth are required for each portion of clayey earth.

+

STRAW

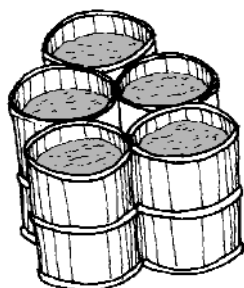


Important:

Straw must be dry with one volume of straw for ten volumes of earth.

+

WATER

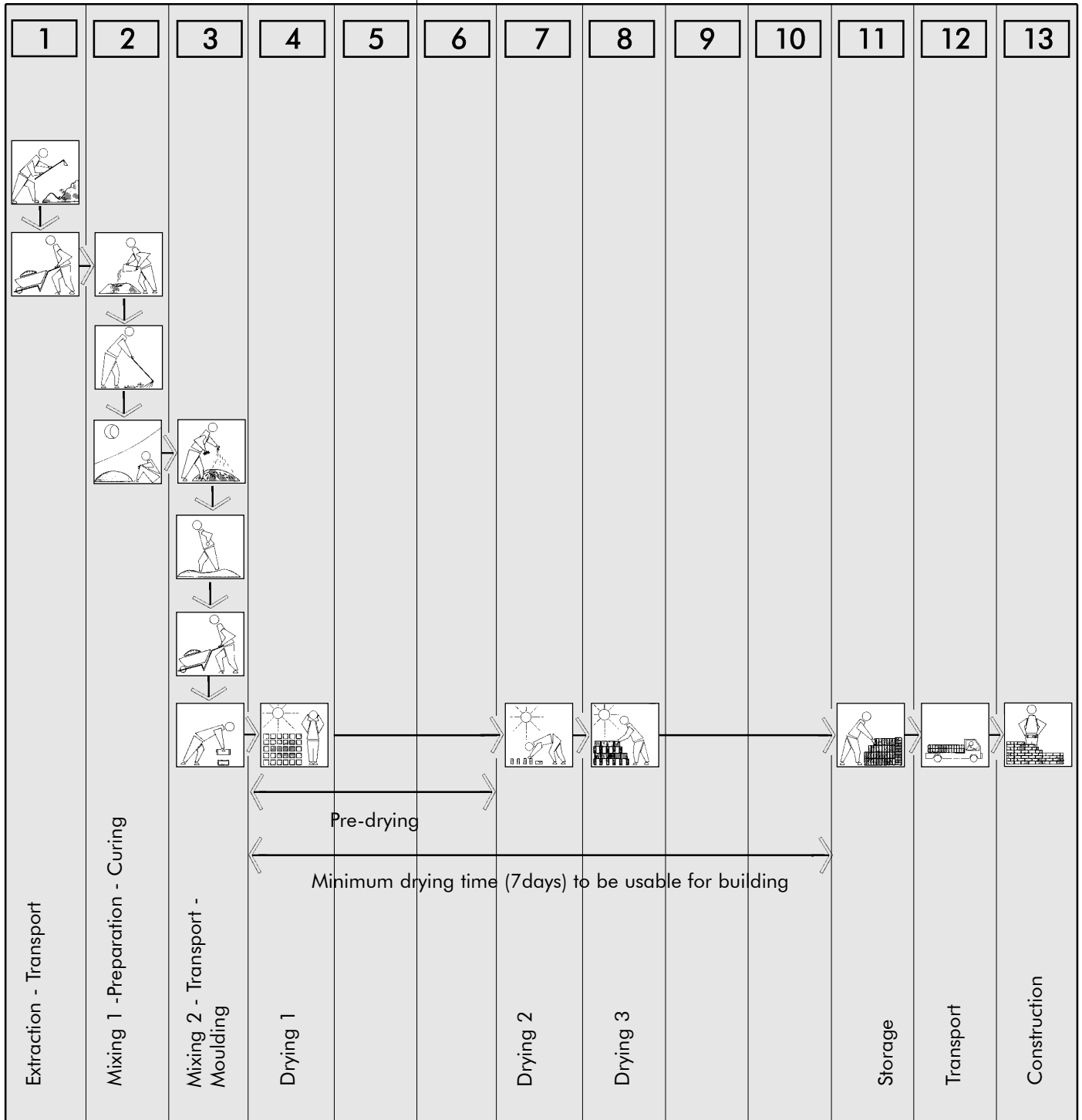


Important:

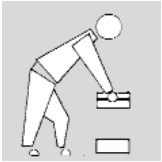
The water must not contain any organic residues, the volume of water needed is approximately 30% of the volume of dry earth.

DIAGRAM OF PRODUCTION DAYS

PRODUCTION DAYS



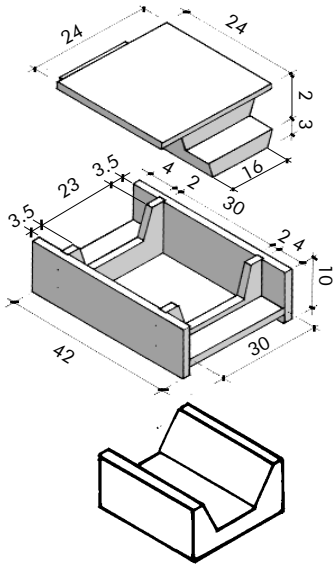
MOULDING & WORKBENCH



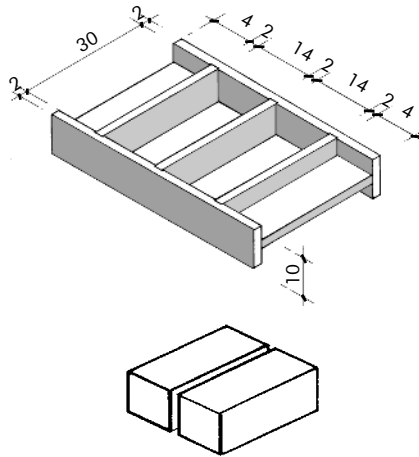
TYPES OF MOULDS

Wood for the 3 basic moulds: 2 de 235 x 9 x 2cm.
 1 de 30 x 15 x 5.5cm.
 1 de 24 x 1cm.

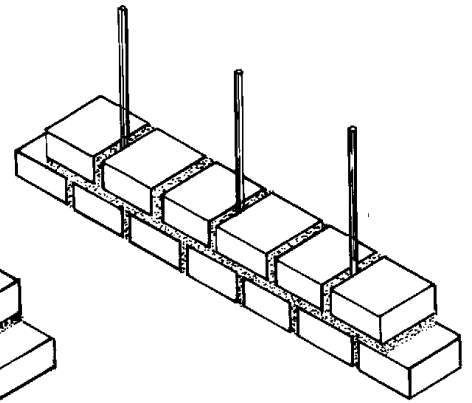
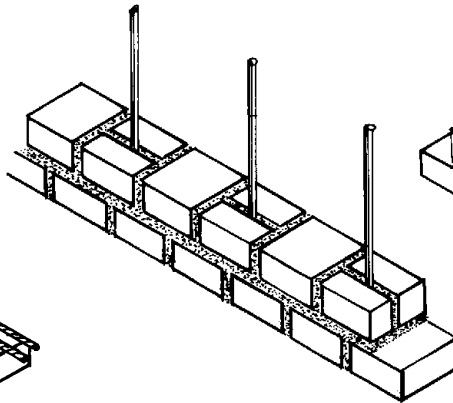
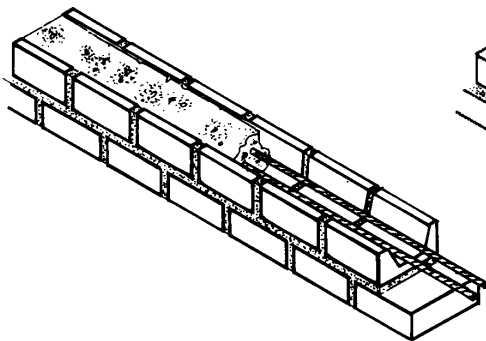
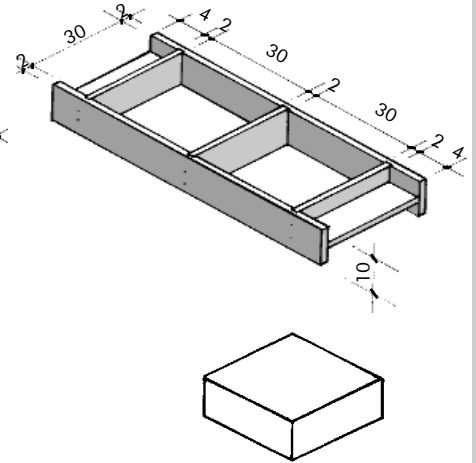
"U" shape



1/2 adobe : 30x14x10

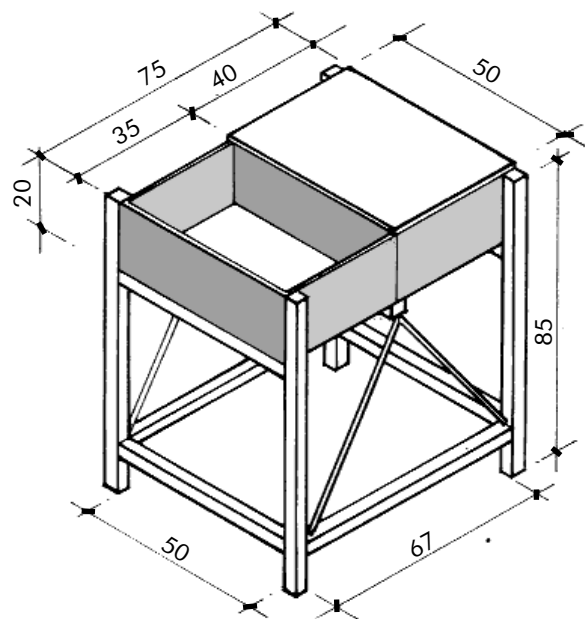


Full Adobe : 30x30x10



WORK BENCH

Wood for the bench :
 - 4 de 4 x 4 x 85 cm.
 - 7 de 4 x 4 x 50 cm.
 - 2 de 40 x 1 x 20 cm.
 - 1 de 50 x 1 x 20 cm.
 - 1 de 50 x 40 x 1 cm.
 Steel container thickness 2mm.
 Dimension: 20 x 50 x 35 cm



MIXING

Mixing consists of two stages: firstly the earth and water are mixed together, then the earth and water with the straw until a homogenous and plastic paste is obtained.



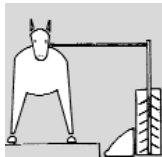
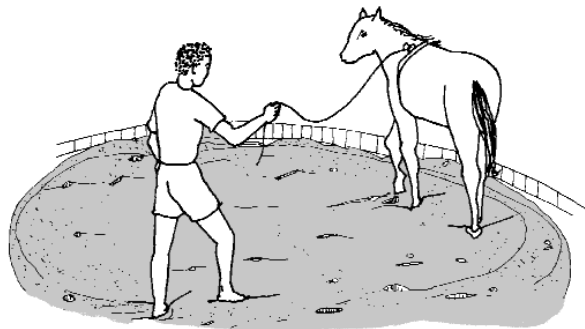
WITH FEET

One of the most common methods for mixing for small-scale production.
4 m³ man/day



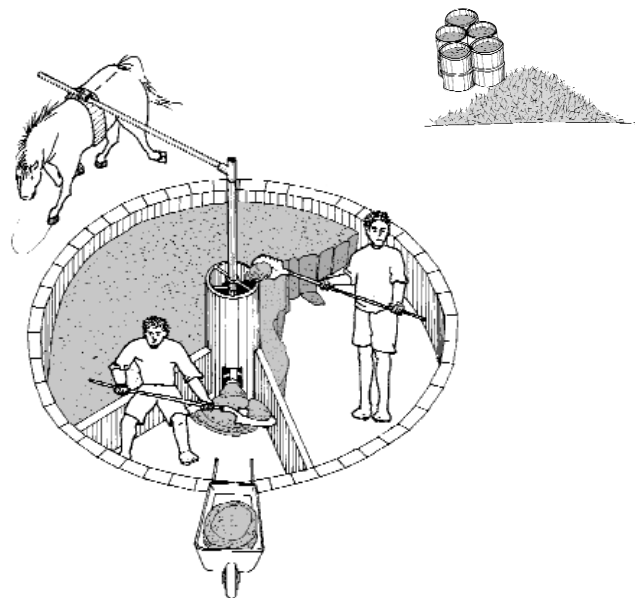
ANIMALS

Work done by animals moving in circles around the work surface.



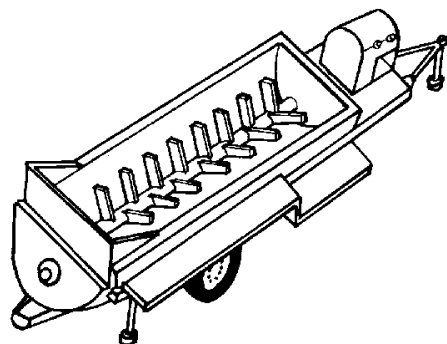
VERTICAL MIXER

Built from rudimentary materials, driven by an animal.



INDUSTRIAL MIXER

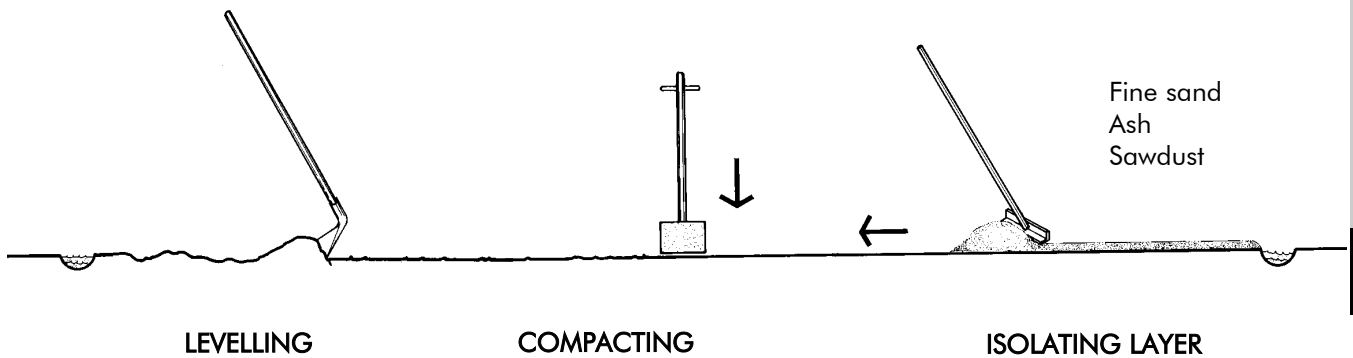
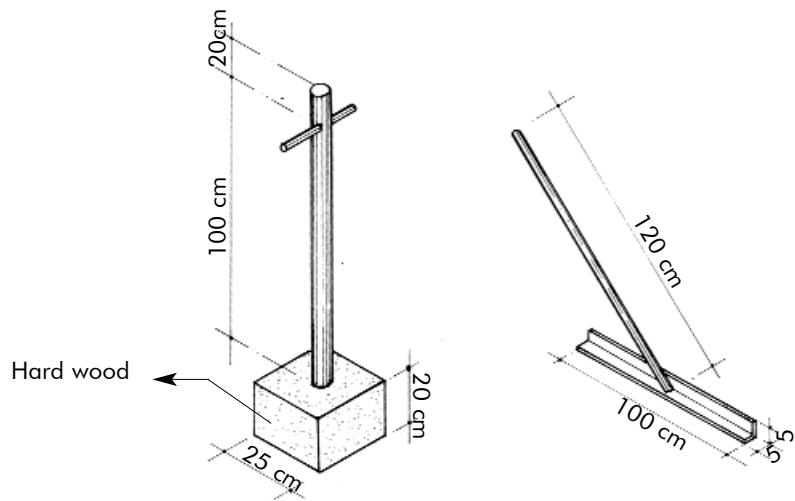
Used in production units with important means and resources.
From 5 to 50 m³ / day



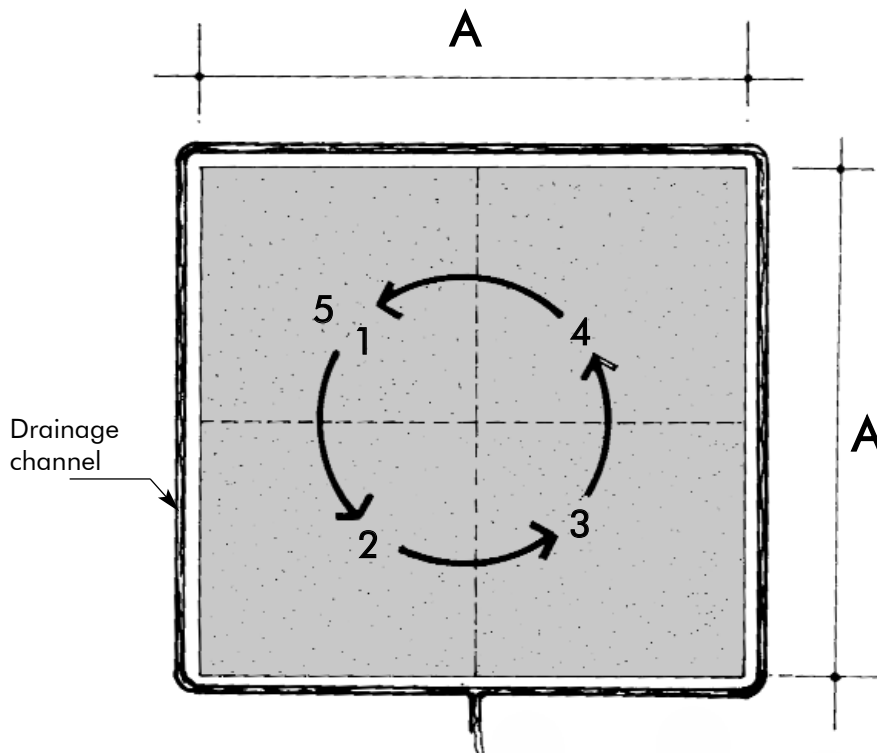
PREPARING THE DRYING AREA

SPACE FOR DRYING:

To correctly dry adobe an area with favourable conditions is required: flat, isolated and delimited.



PRODUCTION AREA



The production area is determined according to the daily yield, the dimensions of the adobe (thickness) and its drying time.

This area will be delimited by a drainage channel for rainwater.

Example :

If $A = 15$ m we will then have 4 days production and $4 \text{ days} \times 414 \text{ adobe bricks/day} = 1656 \text{ adobe bricks}$.

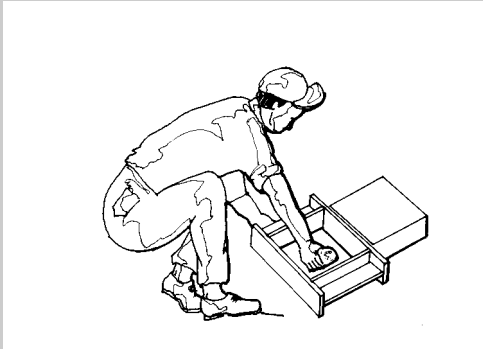
On the 5th day the area can be used again.

MOULDING / REMOVING FROM MOULDS

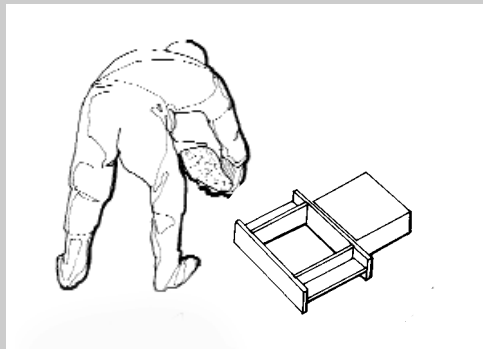


The moulding is made after the earth/water mix has been allowed to rest at least overnight. The next day mix again, this time adding the straw.

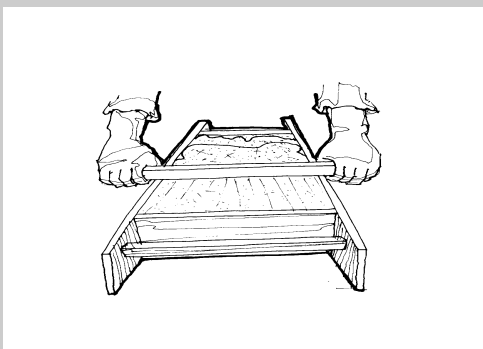
IMPORTANT STAGES



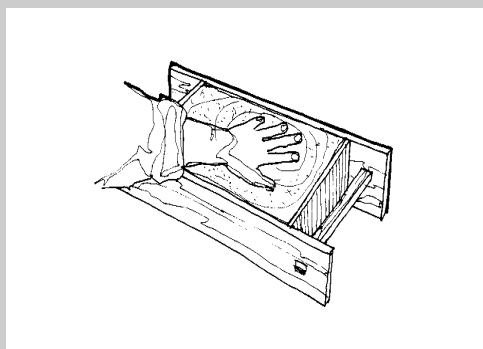
Clean mould



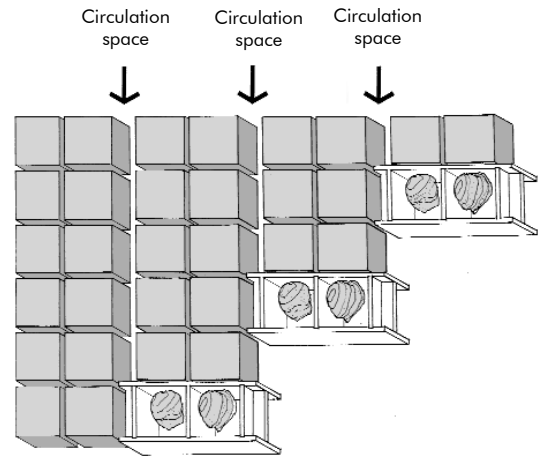
Fill mould



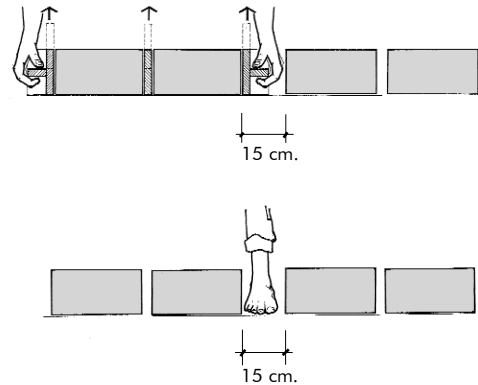
Level out



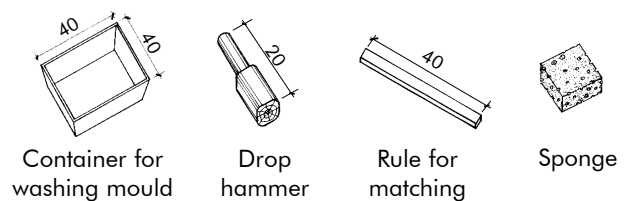
Match with straw



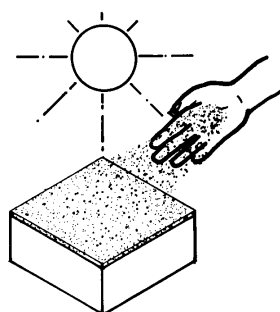
Leave spaces at one metre intervals for necessary circulation. Respect alignment to optimize the use of space and for counting.



TOOLS



BE CAREFUL WITH CRACKS DUE TO RETRACTION AT HIGH TEMPERATURES



Avoid producing during hottest hours, between 11 am and 3 pm.

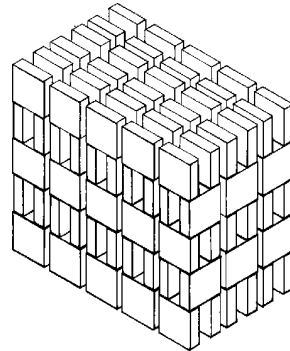
Immediately protect the surface with a layer of sand or ash.

STORAGE / TRANSPORT

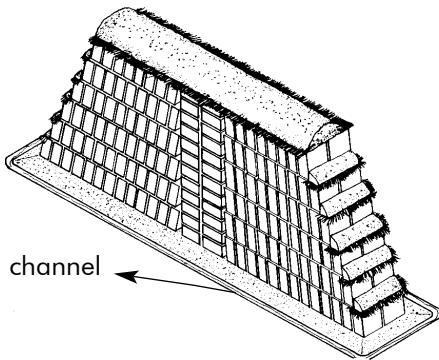
To maintain the quality of adobe it needs to be stored correctly so as to avoid problems caused by rain and humidity.



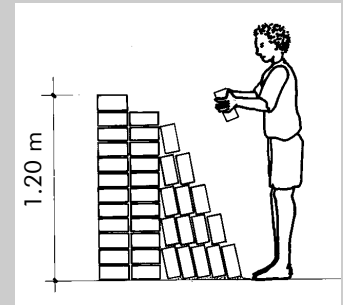
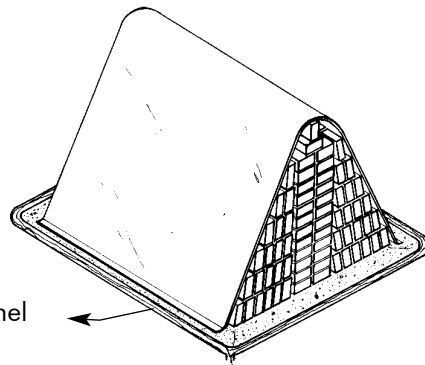
First outdoor storage to continue complete drying of adobe bricks



Type of coverings:



- leaves (banana tree, palm tree, etc.)
- zinc sheets,
- plastic



Maximum height

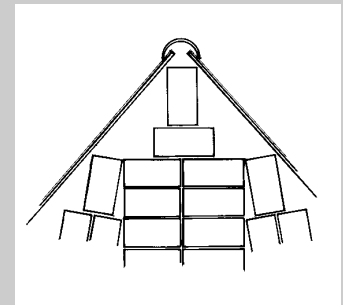
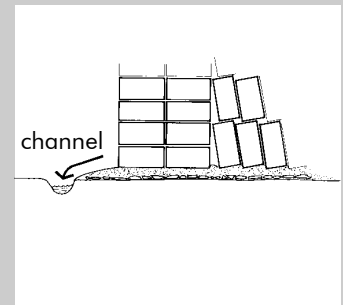
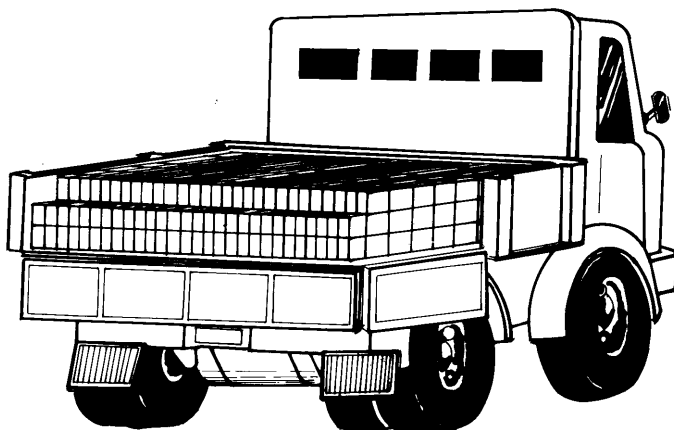


Diagram of mound

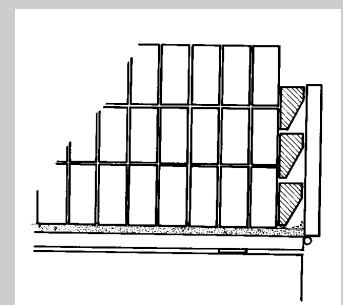


Protective layer of sand, gravel. Surrounding channel.



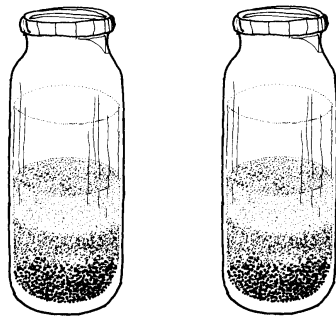
To avoid losing adobe bricks during transport:

- put a layer of sand under the adobe bricks
- block the adobe bricks against the walls of the wagon with wooden blocks.



QUALITY CONTROL

CHECKING THE EARTH



Reference

Sample

Extraction::

Each week, check if the new earth is identical to that selected initially.

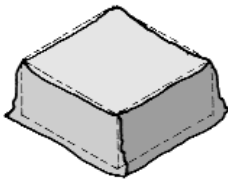
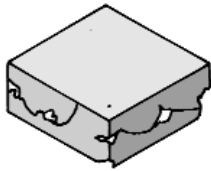
Carry out the "bottle" test (decanting of the earth in water after shaking).

Compare the distribution of the different layers with the reference bottle.

CORRECTION :

When both bottles do not have the same appearance, analyse the earth again to check its properties.

CHECKING THE SHAPE



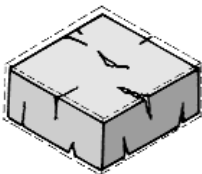
When removing from the mould: :

- No voids are acceptable in the corners
- The base should not increase more than 5%

CORRECTION :

- Push better into the corners of the mould
- Reduce the quantity of water

CHECKING RETRACTION



After removing the mould :

- Cracks quickly appear on the surface

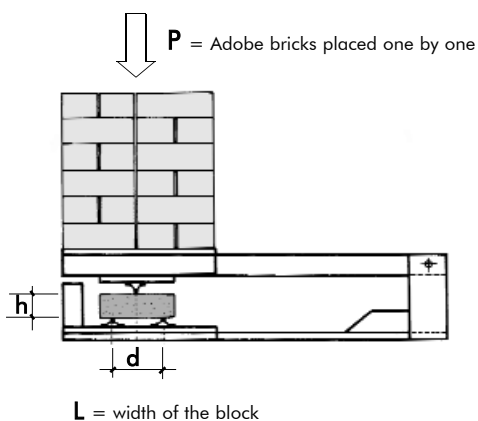
After drying :

- Cracks are more than 5 cm deep.

CORRECTION :

- Protect of the sun
- Check the proportions of earth and straw.

CHECKING RESISTENCE



After complete drying :

Randomly choose 3 adobe bricks from the daily stock. The 3 adobe bricks should have a resistance greater than that required by the "customer-contract". Flexion resistance : **RF**

$$RF = \frac{1,5 \times P \times d}{L \times h^2}$$

Example :

Adobe 30 x 30 x 10 cm , d = 15 cm, mass = 9kg.

Thus: P > 30bloc (Rf > 2.9 kg/cm²)

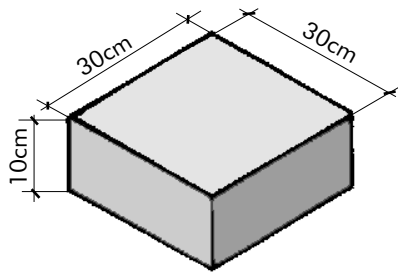
CORRECTION :

- Check the "fermentation" time of the earth before moulding
- Check the cohesion of the earth: if it is too sandy change the source
- Check the percentage of straw

DIMENSIONS OF THE HOUSE

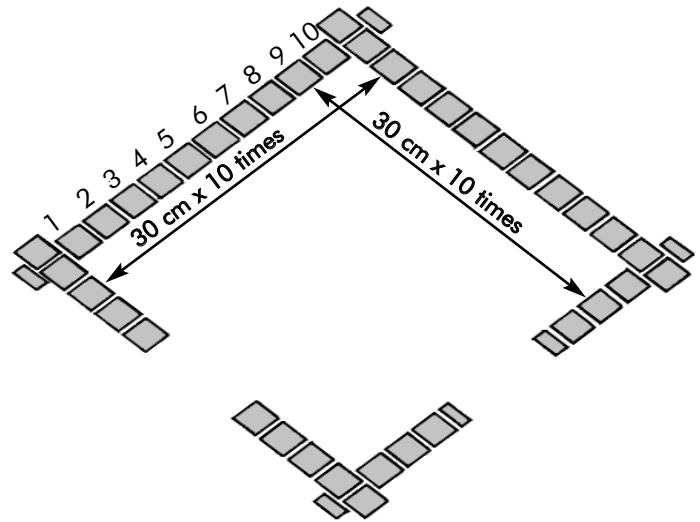
The recommendations and regulations for anti-seismic constructions made from earth have a basic principle: a symmetrical plan, preferably square, with openings centred and small dimensions. The maximum distance from the wall between the vertical supports will be 10 times the thickness of the wall.

With the following adobe brick dimensions :



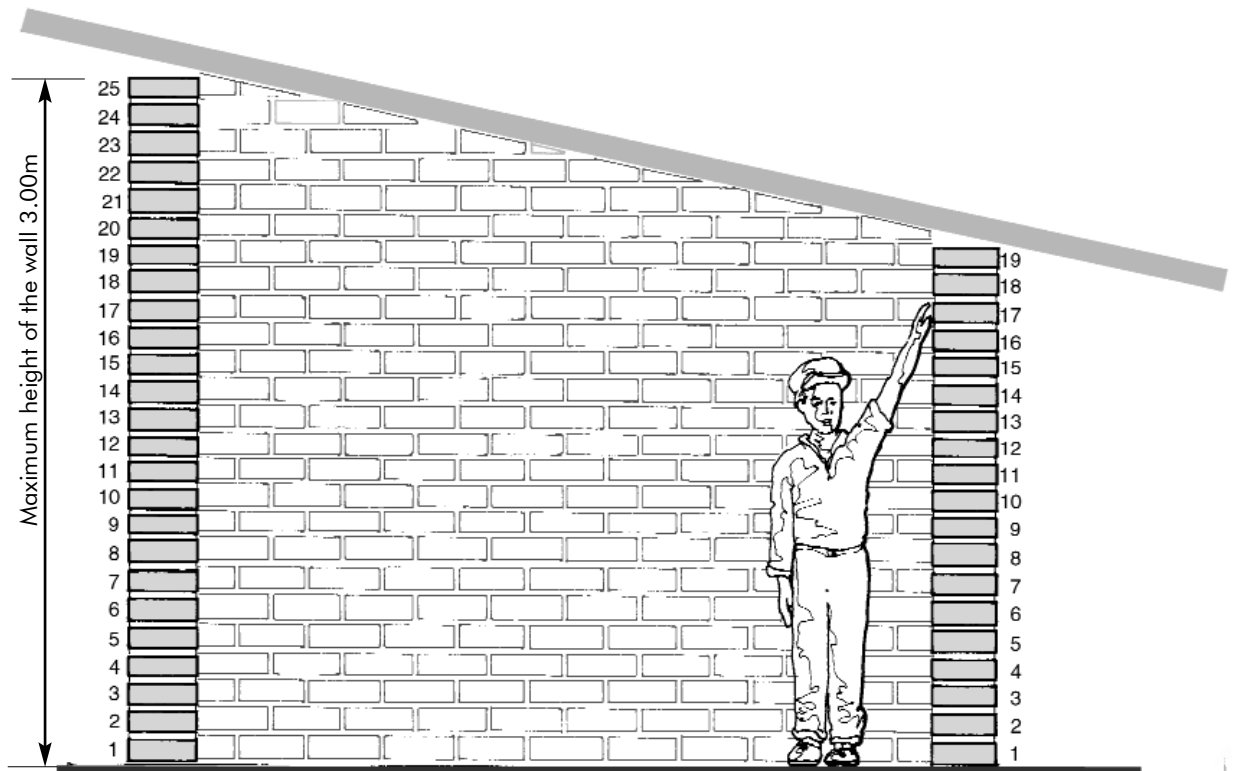
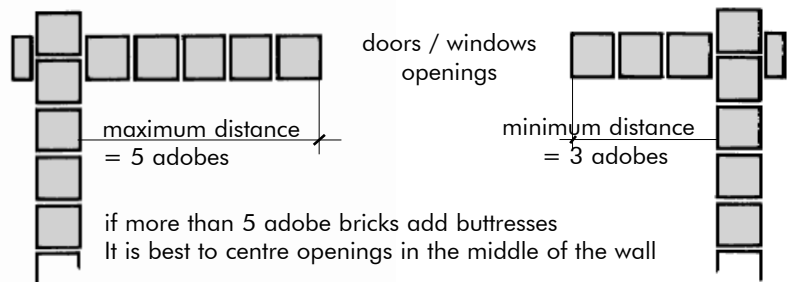
The formula to calculate the maximum dimension of the construction :
 Width of the adobe x 10 times = maximum dimension of the construction

Dimension of the adobe brick
 $30 \text{ cm} \times 10 \text{ times} = 3.00 \text{ m}$
 Then add the joints
 $11 \times 2 \text{ cm joints} = 22 \text{ cm}$
 Thus: $3.00 \text{ m} + 22 \text{ cm} = 3.22 \text{ m}$, this is the maximum dimension of the construction



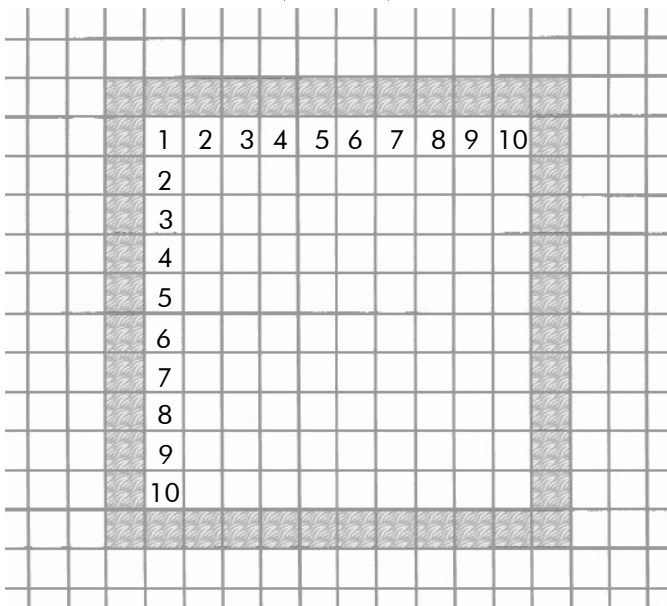
To calculate the maximum height
 Width of the adobe brick x 10 times = maximum height of the wall.

If the height of the adobe brick is 10 cm x 25 times = 2.50 m
 Adding the 25 joints x 2 cm = 50 cm
 Final height of the module = **3.00 m**



DESIGN OF THE HOUSE

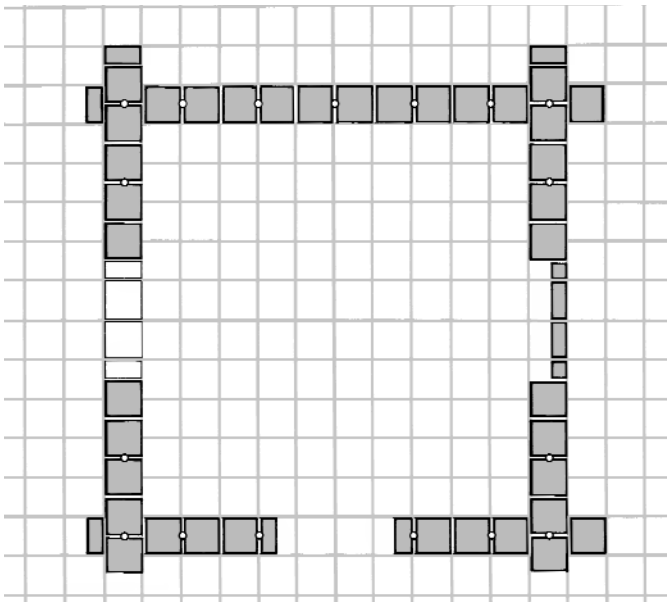
INITIAL LINES



If you wish to build the house start with the first module:

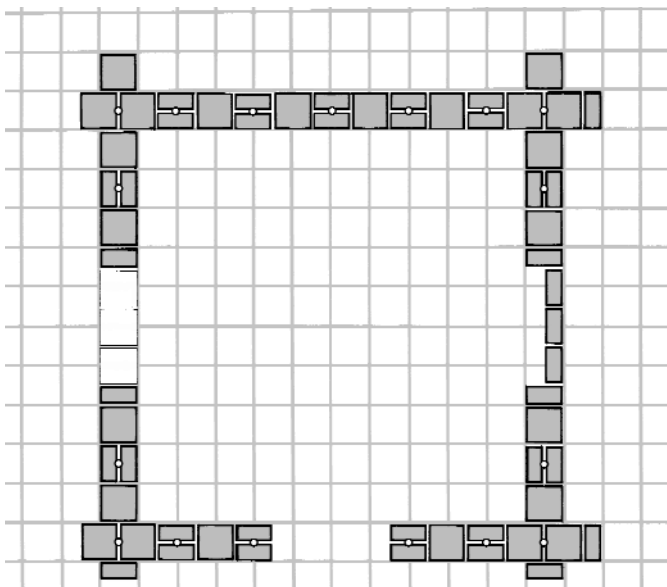
1. take a pen and squared paper.
 - then count each square as an adobe brick before counting the number of adobe bricks (10)
 - finally mark out the area where the walls will be built.

FIRST ROW



2. position the adobe bricks in the first row taking into account that for a good overlap you will need to use middle blocks.
 - locate the openings (doors and windows)
 - also locate the buttresses.

SECOND ROW



3. position the second row and check the overlap with the first row.
 - take into account the location of the vertical reinforcements.

DEVELOPMENT OF "LA SEMILLA"

The dimensions of the house are developed with a module known as "La Semilla", which satisfies anti-seismic requirements. It is from this module that successive enlargements are made.

The size and growth of the house depends on economic conditions, availability of materials and time.

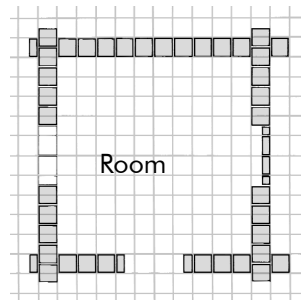
If conditions permit we can go directly to the final step.

LA SEMILLA

Living space = 10.36 m²

Full size adobe bricks = 806 units

Intermediate adobe bricks = 295 units

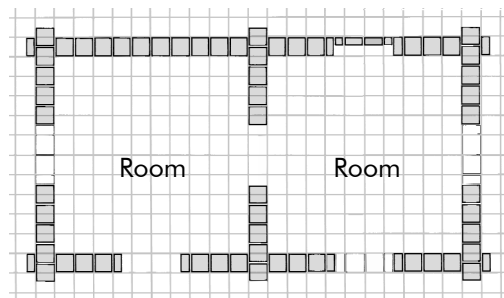


BASIC FARMHOUSE

Living space = 20.74 m²

Full size adobe bricks = 1430 units

Intermediate adobe bricks = 539 units



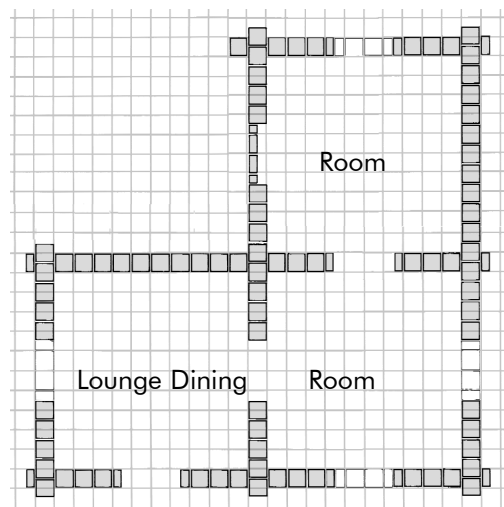
INTERMEDIATE HOUSE

Living space = 31.08 m²

Full size adobe bricks = 2054 units

Intermediate adobe bricks = 783 units

NOTE: These forms are not equal to a rectangular or L-shaped house. Here it is the sum of the modules duly supported.



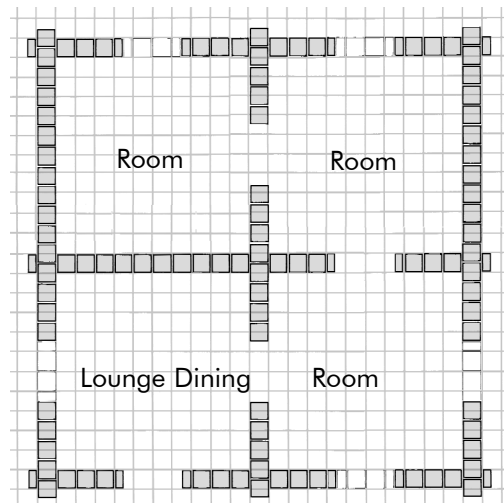
COMPLETE HOUSE

Living space = 41.44 m²

Full size adobe bricks = 2454 units

Intermediate adobe bricks = 930 units

IMPORTANT : The kitchen area is not considered here because traditionally it is located in an annex. If conditions permit "La Semilla" can be considered a kitchen.

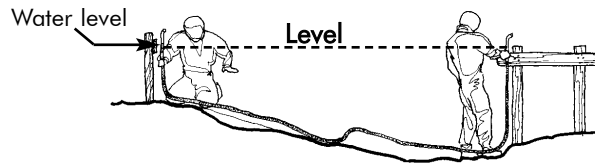


TRACING OUT & PLANTING

The first operation carried out when beginning to build the house consists of tracing out the design on the ground. It is important the house is correctly traced out since this will condition the success of the following steps of construction.

1- Vertical level. Using a transparent hosepipe and water:

- check the % of difference in ground level
- set the height of foundations
- transfer the heights from one side to the other.



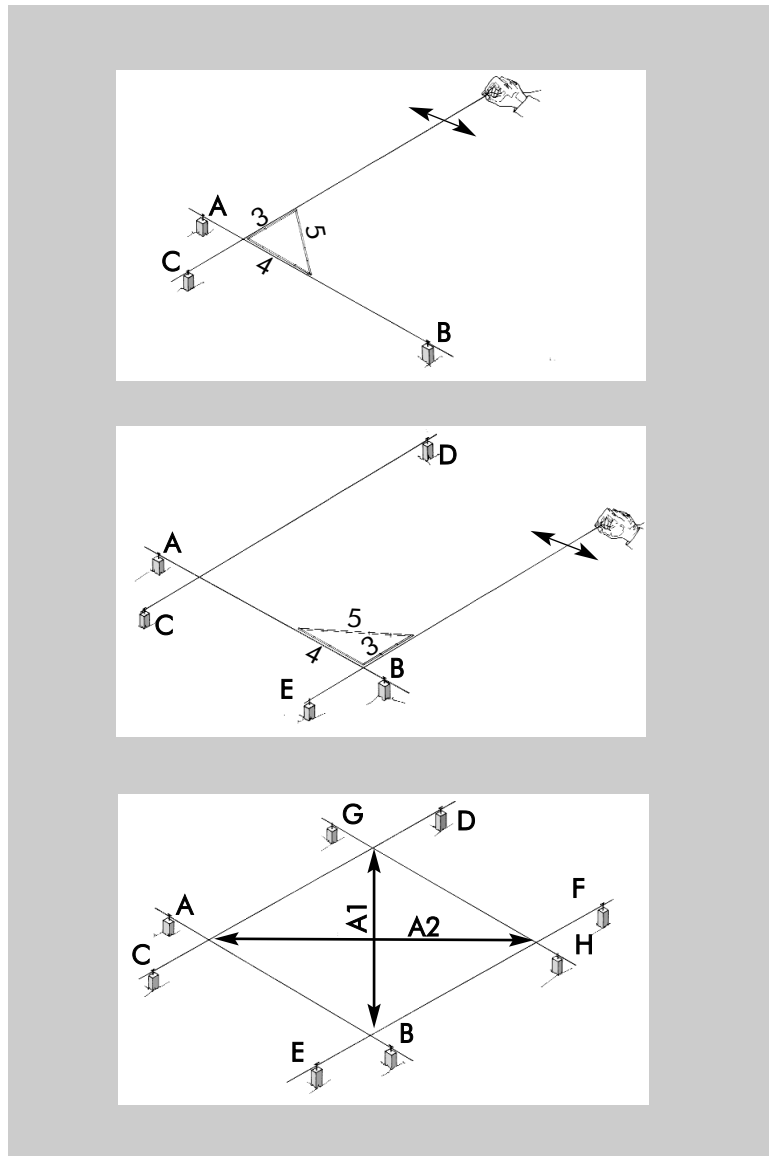
2- Tracing out. Once the ground has been prepared: clean and level out. Using temporary stakes and string trace a line AB which we shall refer to as the "master" or reference line.

To trace the orthogonal line CD (right angle) to the "master" line, use the 3,4,5 method, ie. make a right angle using a decametre.

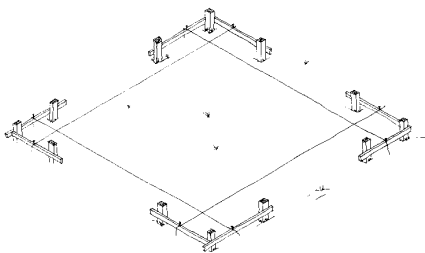
Situate the cross point, set point D and draw the string towards point E aligning the previously defined right angle.

The next orthogonal line EF is traced out in the same way as above.

Finally, line GH parallel to the master line, before taking the required distances.

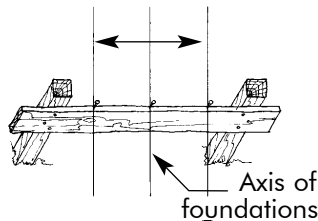


Fitting the stakes and barriers



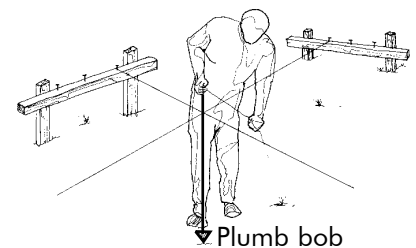
Once the area has been demarcated, check if the angle is correct on all 4 sides by measuring the two diagonals $A1 = A2$.

Width of foundations



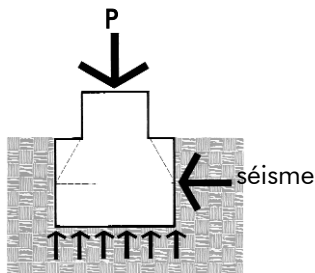
Then fit the definitive stakes with the aim of defining the axis and width of the foundations and the wall with the house's definitive dimensions.

Marking out the limits of the trench



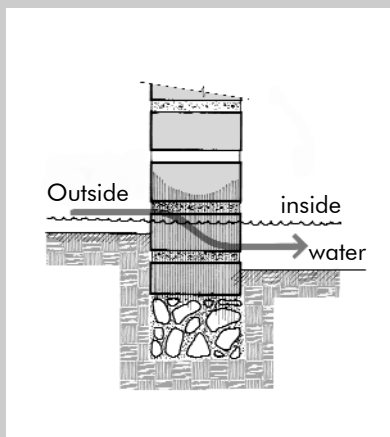
The points are then marked out on the ground for tracing out and digging, using a plumb bob and string

FOUNDATIONS



The purpose of the foundations is to transfer the load of the construction onto the ground. The weight of the structure must be suited to the load capacity of the ground which must furthermore be stable. The structure must also be correctly joined and anchored to the foundations.

PROBLEMS - PATHOLOGIES: inadequate foundations

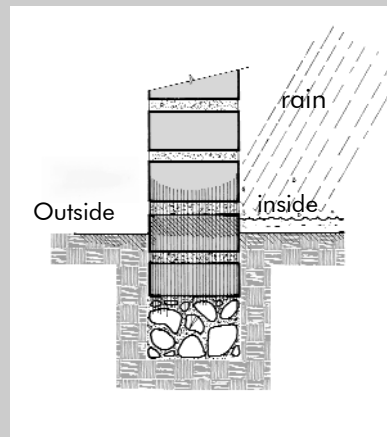


Flooding

The foundations need to be solid and the wall base must be approximately 20cm above the level of the ground on the outside in order to avoid:

- the wall absorbing humidity when it rains.
- flooding if the level of the inside floor is lower than outside.

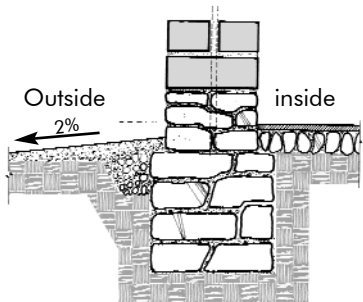
If the above occurs the walls will be weakened and will easily collapse in the event of an earthquake .



Absorption of humidity

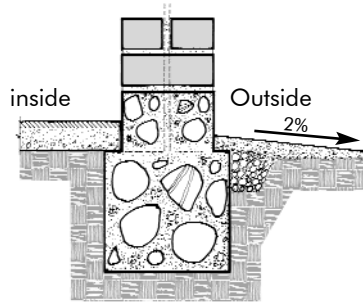
TYPES OF WALL BASE & FOUNDATIONS

The type of material used for the foundations will depend on the availability of the material, its cost and implementation time.



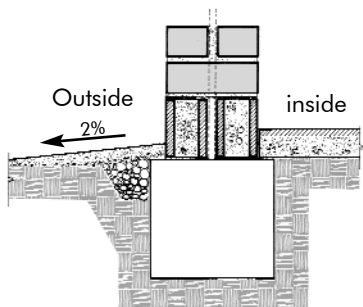
Stone masonry cement

The minimum width of the foundations will be 40cm. Nevertheless it is advisable to use a ratio 1.5 times the width of the wall..



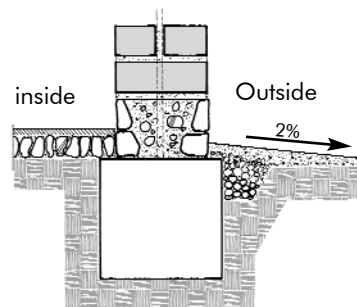
Cyclopean concrete

ALTERNATIVE WALL BASES



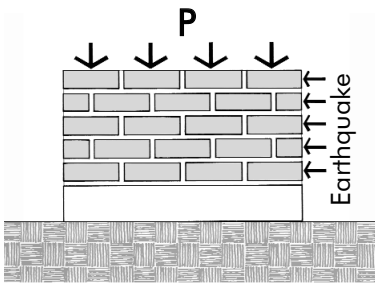
Wall base with concrete blocks (40x20x14cm) and concrete filling.

The minimum height will be 20cm.



Wall base casing with stones and concrete filling.

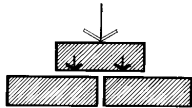
WALLS



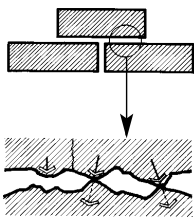
A load bearing wall transmits the loads its receives from the roof plus its own weight onto the foundations.
In the event of an earthquake, the wall supports loads perpendicular to its plane.

POSITION OF THE ADOBE

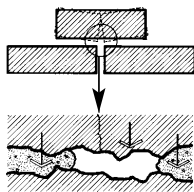
POSITION OF THE MORTAR



Well filled mortar joints help to distribute loads



Inadequate mortar filling does not distribute loads correctly and makes the block crack

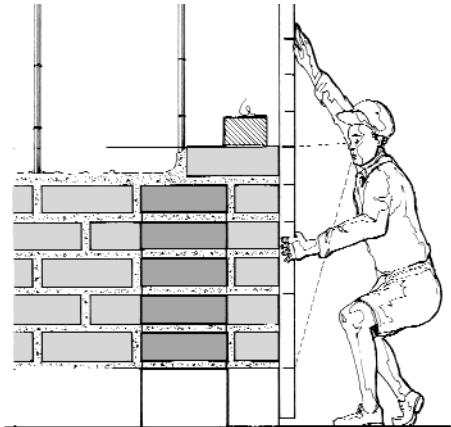


Incorrect use of mortar: spaces



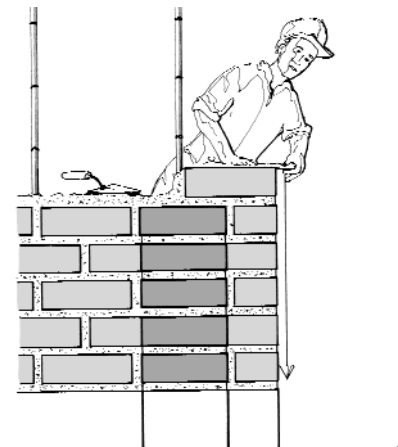
Correct use of mortar

CHECKING THE HEIGHT



Use a 12cm graduated ruler (adobe+join) and check the height each time you add the master adobe brick.

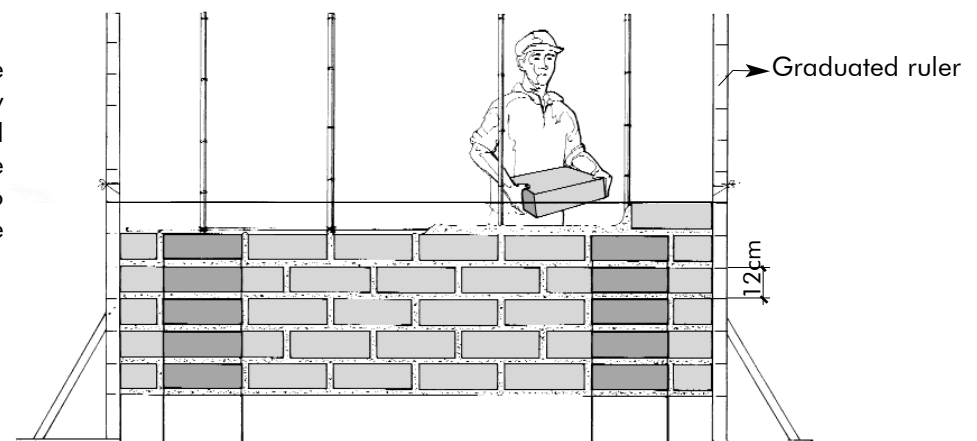
CHECKING VERTICALITY



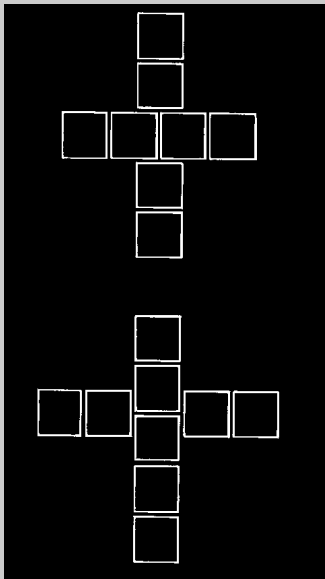
Using a plumb bob we can check the verticality from the master block to the first row.

ALTERNATIVE FOR CHECKING VERTICAL AND HORIZONTAL LEVEL

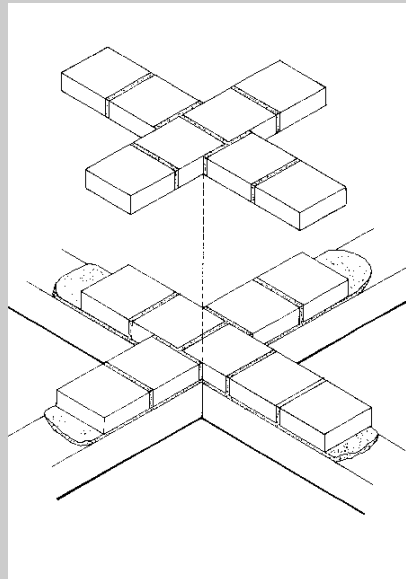
An efficient way of checking the horizontal level and verticality of the wall is to fit graduated rulers on the 4 sides of the building. This enables you to work faster but it is also more expensive.



BONDING SIMPLE WALLS

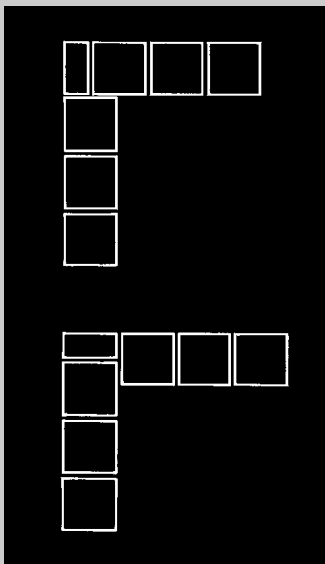


Second row

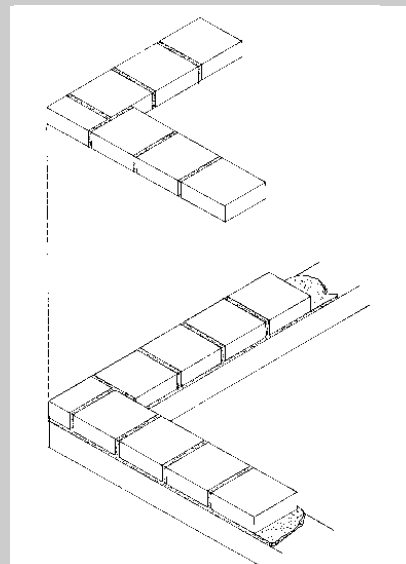


First row

+ shaped walls bonding, bonding of the first and second rows

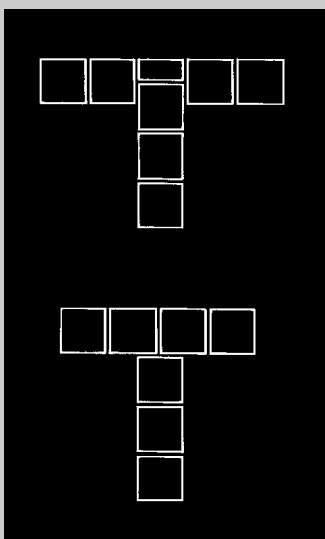


Second row

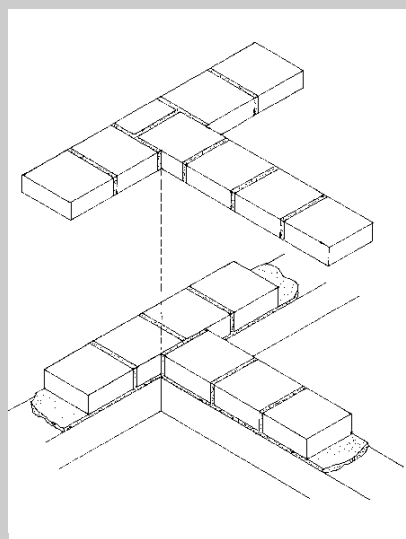


First row

L-shaped walls bonding, bonding of the first and second rows



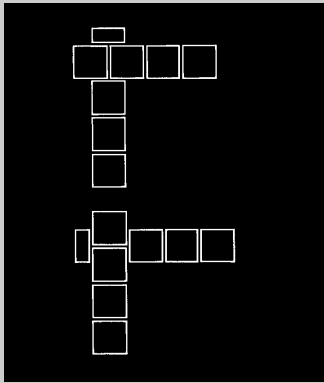
Second row



First row

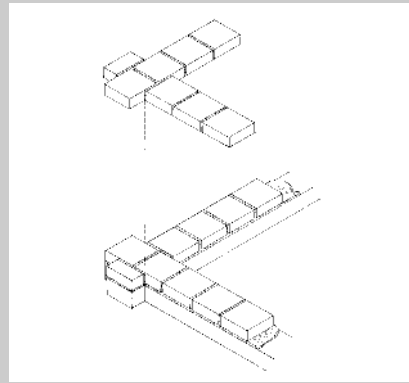
T-shaped walls bonding, bonding of the first and second rows

BONDING REINFORCED WALLS

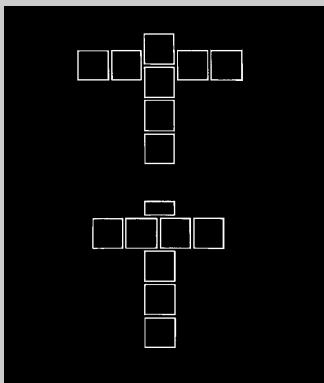


Second row

First row

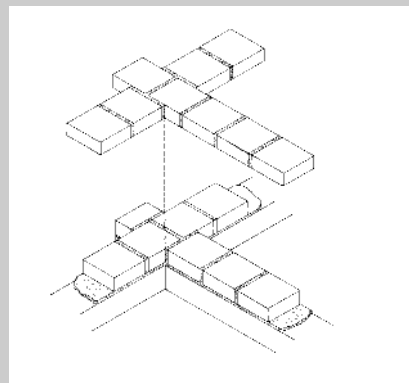


Corner wall bonding, with buttress

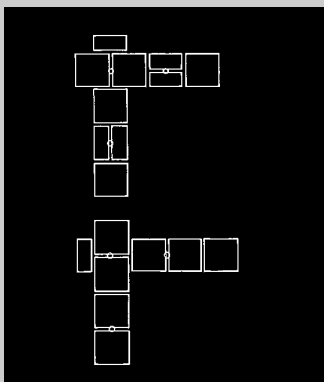


Second row

First row

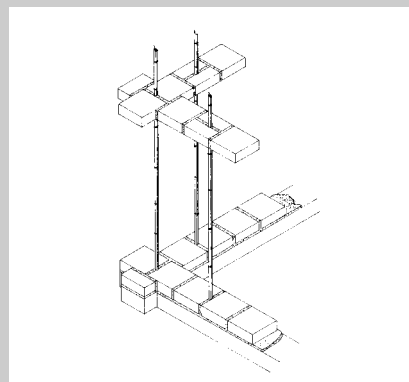


Intermediate wall bonding, with buttress

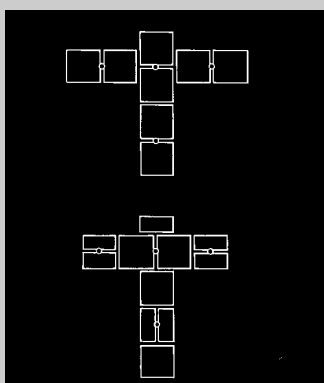


Second row

First row

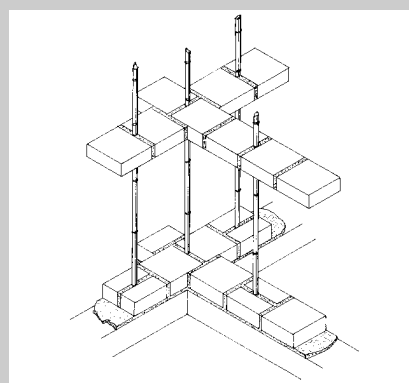


Corner wall bonding, with vertical supports



Second row

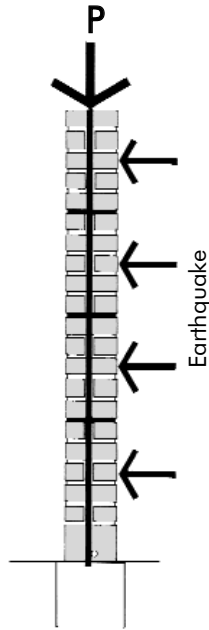
First row



Intermediate wall bonding, with vertical supports

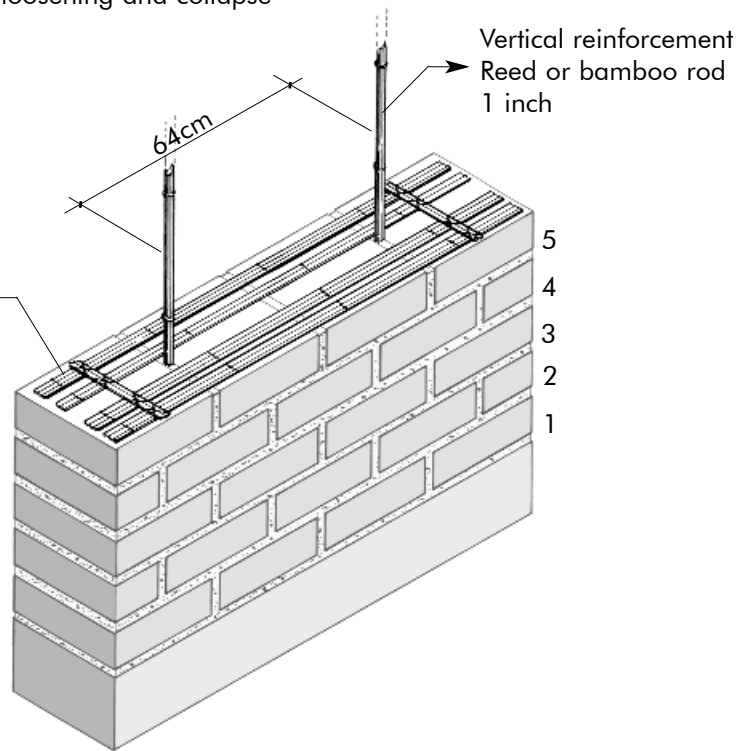
REINFORCEMENTS

Vertical and horizontal reinforcements increase the resistance of walls in the event of an earthquake. Fitting reinforcements inside the walls improves their stability, avoids them separating at corners and therefore prevents their loosening and collapse



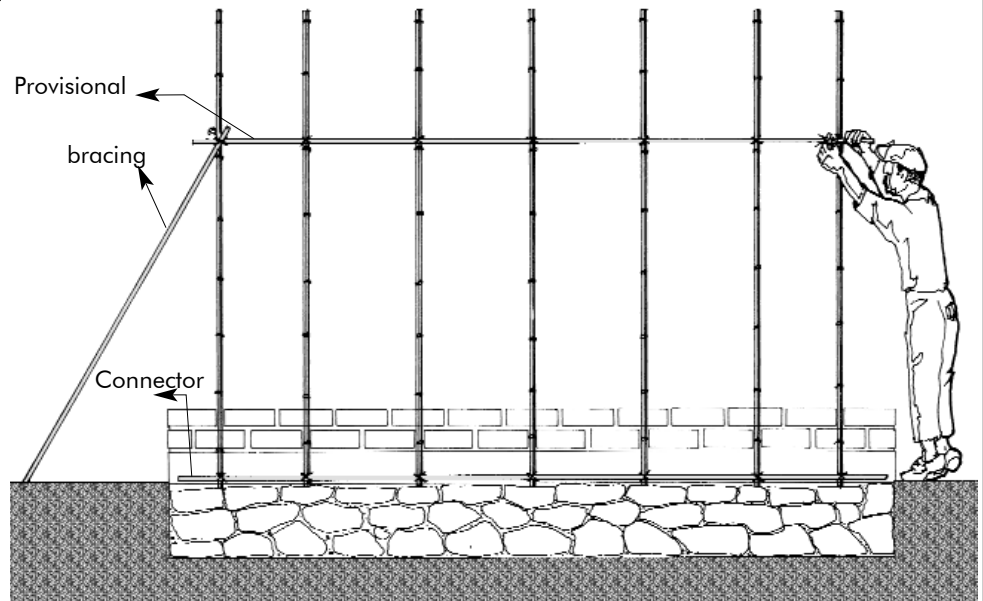
DIMENSIONS

Horizontal reinforcement
Split bamboo or reed rods fitted at intervals of 5 rows

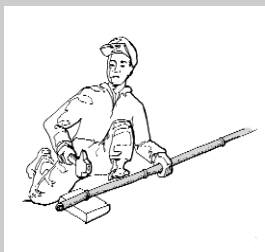


FITTING

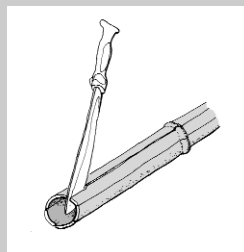
Once you have defined the position of rods fit them vertically using a horizontal connector at the bottom (wall base) and another at the top. These connectors will help us to maintain the rods vertical as the wall is being built, so they are only provisional. We should also support the sides by fitting diagonal struts.



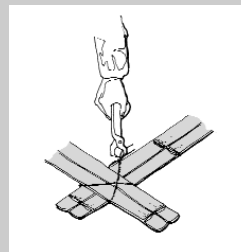
FITTING DETAILS



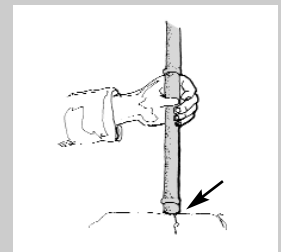
Break the rod's knots.



Open the rods on one side only.

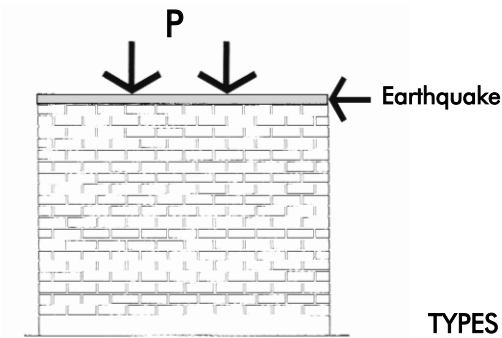


Join at corners with wire.



Always cut rods after a knot.

RING BEAMS



The ring beam is a ring or strap which surrounds the top of the building so as to spread forces in the event of an earthquake. It also:

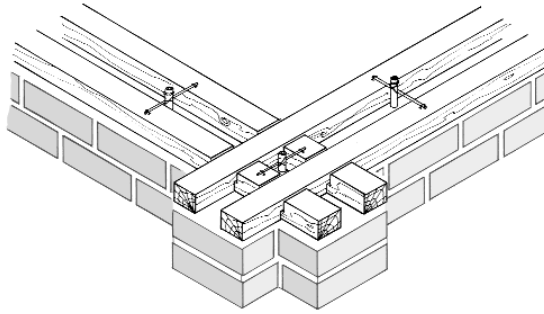
- provides continuity between the transversal walls.
- increases resistance to flexion.
- provides greater continuity between the roof and wall.

TYPES OF RING BEAMS

WOODEN BEAMS

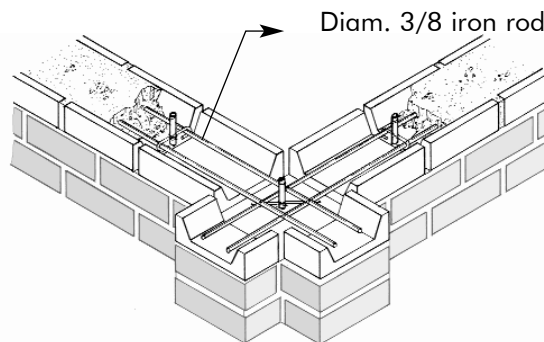
In areas where wood is accessible this is the quickest solution, it needs to be correctly joined in the corners (dovetail).

10x10cm beams are recommended.



U-SHAPED BLOCK

Quick to fit, but requires stabilised U-shaped blocks with a cement-sand proportion of 1:8.



REINFORCED CONCRETE BEAM

A costly alternative, requires wooden casing and drying time.

Diam. 3/8 iron

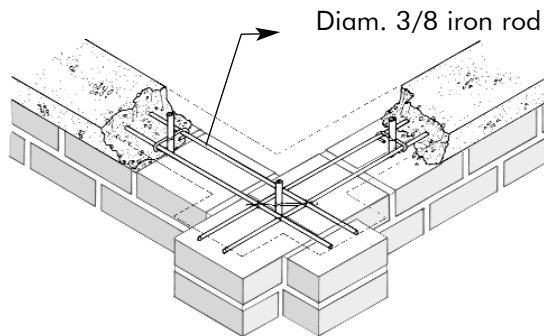
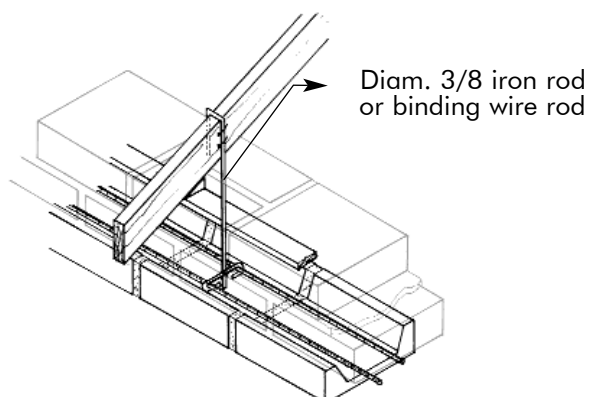
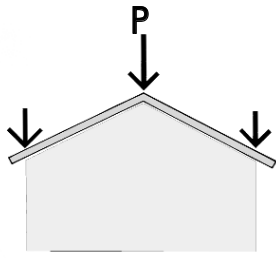


DIAGRAM OF ROOM JOIN

Whatever solution is chosen it is important you join the beam to the roof so as to provide resistance to the forces of a cyclone.



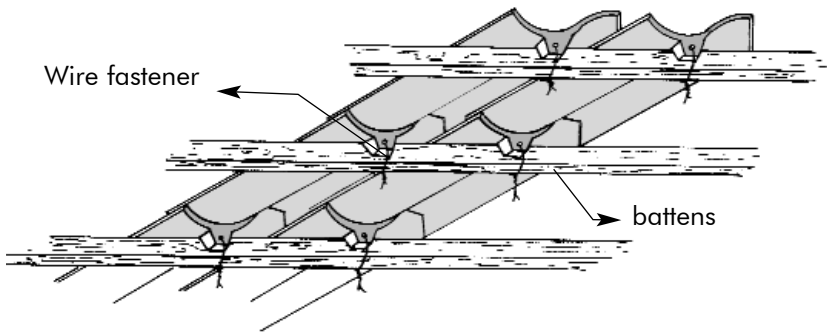
ROOFING STRUCTURES



The roof: the structure and cover behave like a diaphragm (rigid and flexible) which resists flexion and breaking.
 A house in an area prone to earthquakes requires a light roof which distributes its load evenly on the walls.
 The eaves also need to be considered part of the wall's protection and should neither be less than 50cm nor greater than 1m.

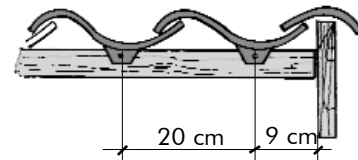
TYPES

MICRO-CONCRETE TILES

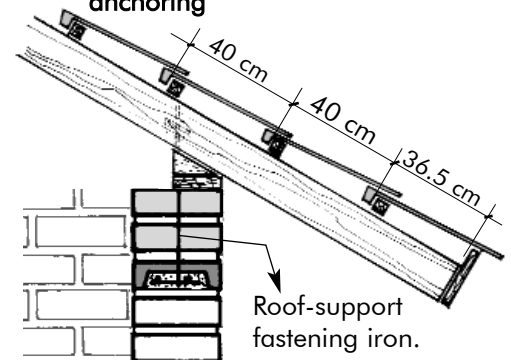


Micro concrete tiles better insulate the inside environment from heat and the noise of rain.
 However they require a uniform structure and a greater number of battens.
 12.5 units of tiles are needed for one square metre of roofing.

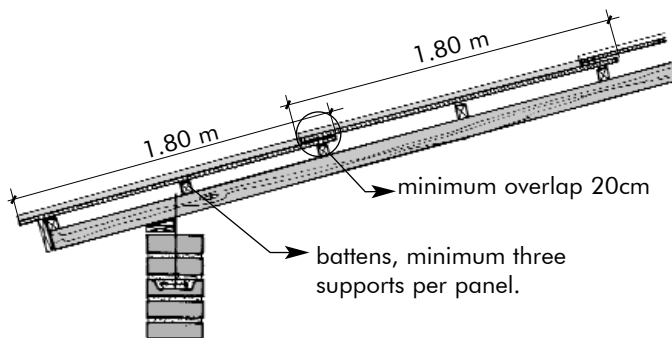
Lateral installation



Detail of overlap and anchoring



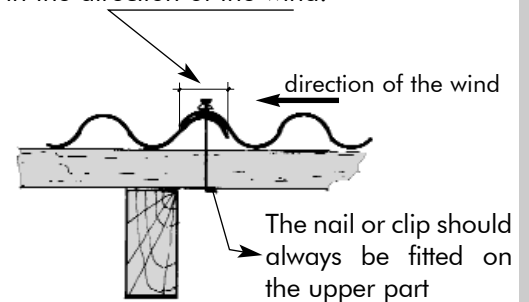
CORRUGATED PANELS



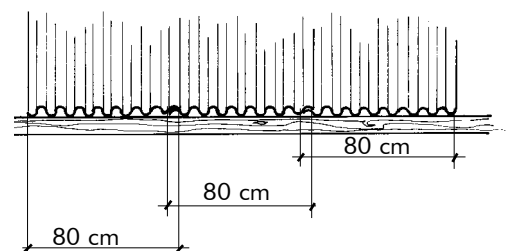
Corrugated sheets, (Zinc) are easy to fit onto a house and are also economical, but they let heat and noise in. Once it is perforated the entire panel needs to be replaced.
 For a 1.20m² roof 1 panel is required.

Overlapping and securing

On roofing sheets with small corrugations (25mm) the overlap is one full undulation in the direction of the wind.



Lateral overlapping



PLASTERING

Treatment applied to the surface of the wall with the aim of protecting it against the weather and use. Also used to make the house more aesthetic.

A wall protected by facing will be in better conditions in the event of an earthquake

Plastering includes several steps:

1. Preparation:

Clean the wall in order to eliminate any loose soil or sand, to guarantee the adherence of the plastering to the wall section. If the wall is wet, you should wait a while for any water inside the wall to evaporate and be absorbed.



2. The underlay:

Used to level out the wall's imperfections and so it can receive this finishing layer.

The thickness of this layer will be between 8mm and 20mm.

The mortar must have the following proportions:

1 part of earth at 5mm diameter.

2 parts of sand (which go through the 5 mm mesh)

1/3 of straw cut into 3cms strips.



3. "Incisions"

Before the first layer, dries, "incisions" are made using a metal brush or nails. This improves the adhesion of the second layer onto the first.



4. The second layer: "the finish".

An aesthetic thin seal or protective layer, added once the first layer is completely dry.

The thickness is between 1 and 2mm.

The mortar will approximately be:

1 part of earth (which goes through the 2mm mesh)

3 or 4 of fine sand.

When making the plaster it is important to test different mixes, changing the proportions until the right mix which does not crack and which is resistant is achieved.



5. Sealing

Use a sponge making circular movements then wait for between 15 and 20 minutes before using a dry paint brush in straight movements, the aim is to seal the surface.

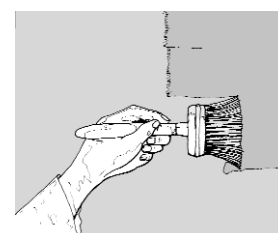
Alternatives: there are other alternatives and combinations.

Lime and sand,

Lime, sand, earth,

Gypsum and sand,

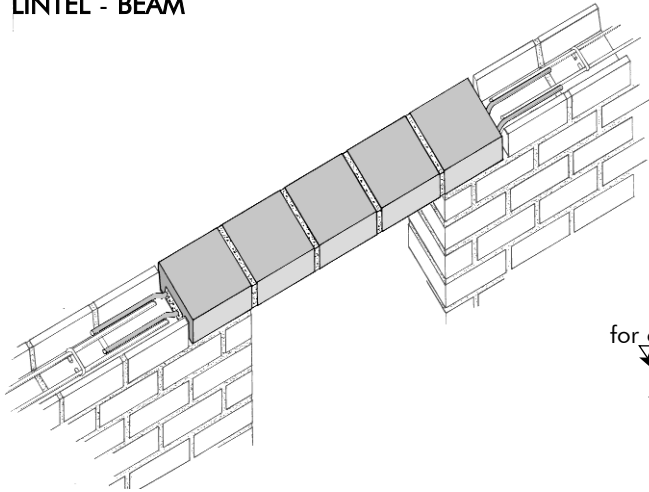
Gypsum, lime and sand



PREFABRICATED ELEMENTS

Prefabricated parts help reduce the construction time required. They can be produced in advance of the construction and are ready for fitting when necessary without interrupting the following stages.

LINTEL - BEAM

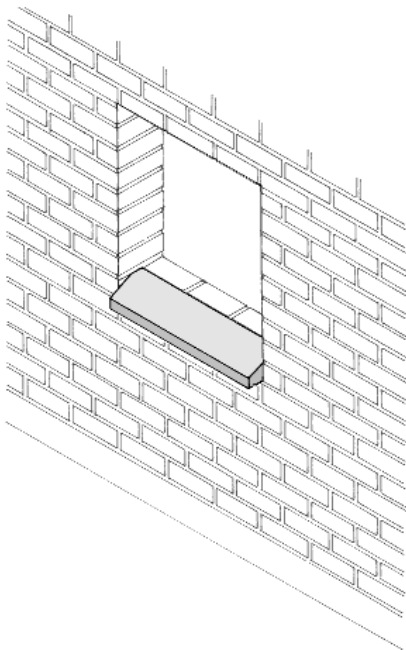


Add by fitting stabilised U-shaped blocks (1:8) on a flat floor, the blocks are spaced at 2cm intervals or which correspond to the distance from the door or window.

Prepare a fortnight before fitting onto the wall.

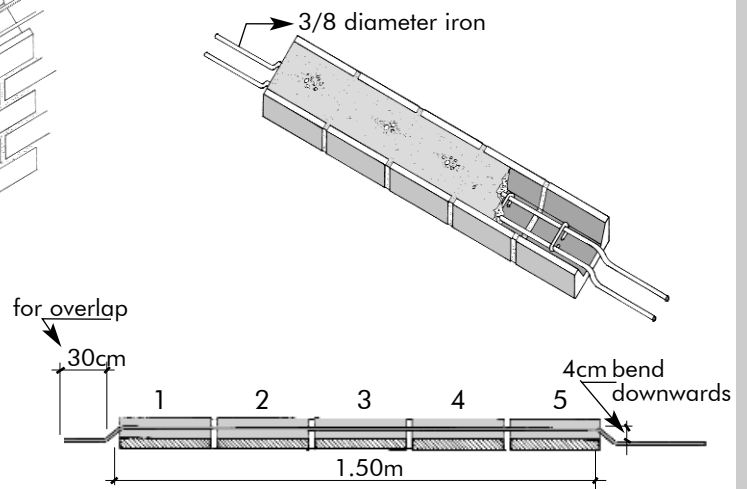
- Mortar
- Sand 2 parts
- Gravel 2 parts
- Cement 1 part

WINDOW SILL

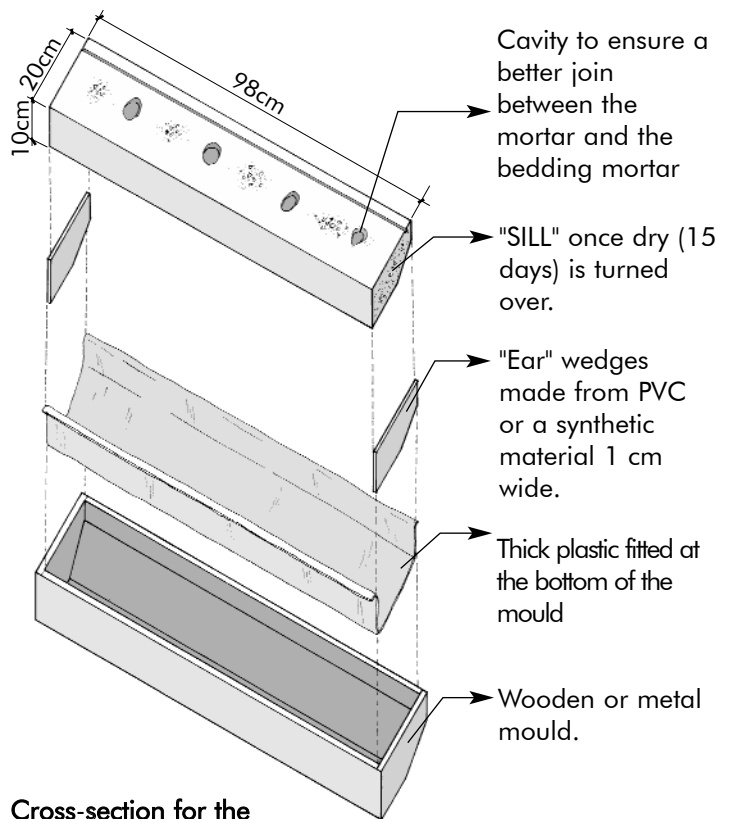


This element is important for protecting the wall below the window.

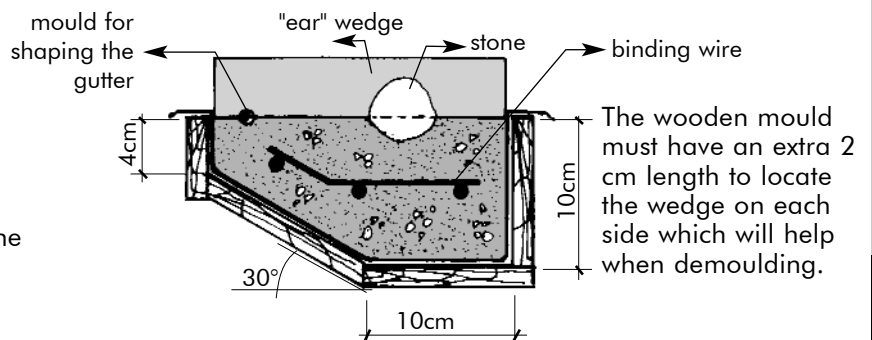
Production



Example of assembly



Cross-section for the "casting" of the window sill.



APPENDIX

- SEMILLA
- FARMHOUSE

"LA SEMILLA"

FIRST ROW GROUND FLOOR

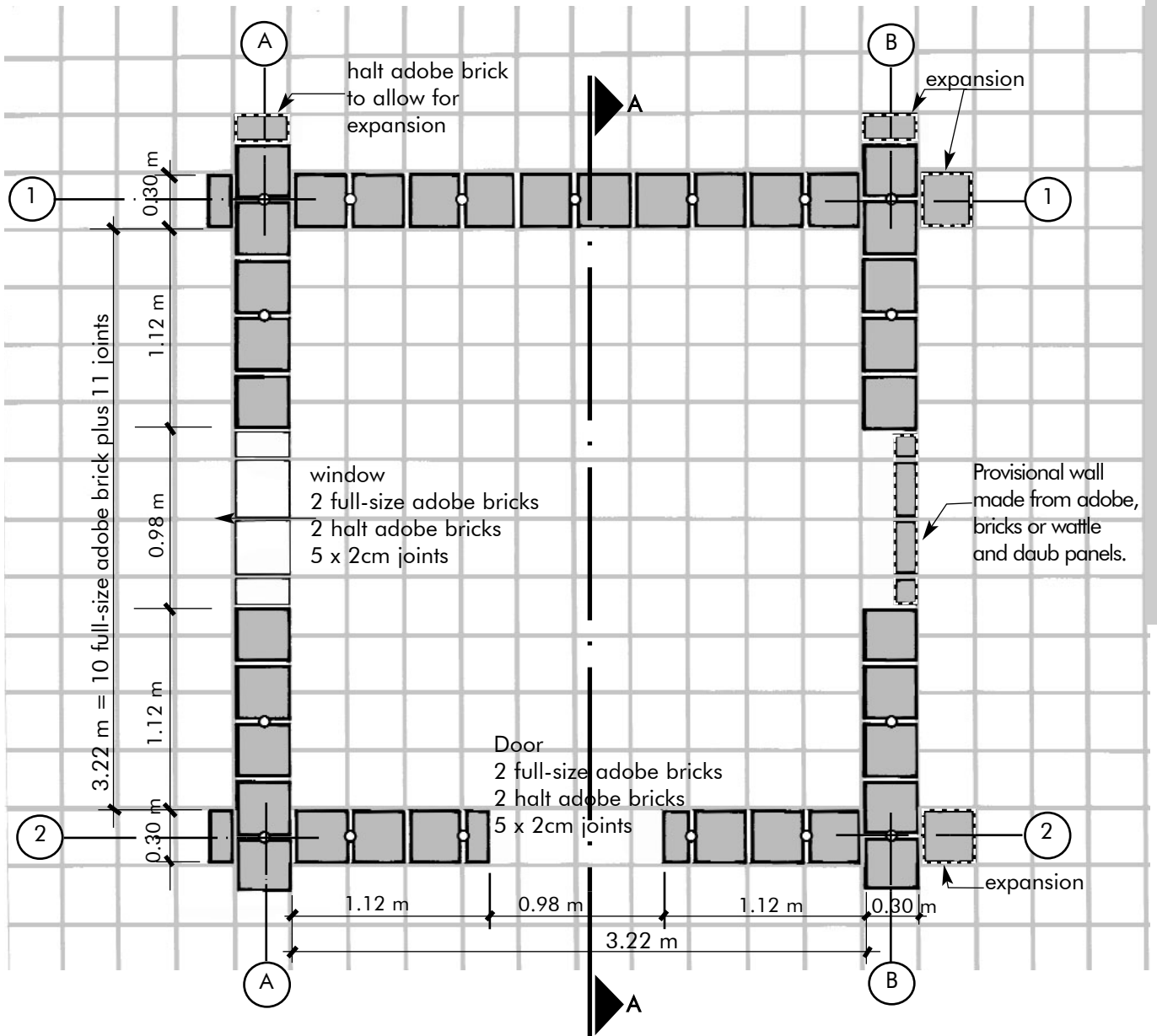


TABLE OF HORIZONTAL DISTANCES IN THE ADOBE WALL

Free-standing wall	"L" shape wall	"U" shape wall
1 adobe = 0.30m	0.32m	0.34m
2 adobe = 0.62m	0.64m	0.66m
3 adobe = 0.94m	0.96m	0.98m
4 adobe = 1.26m	1.28m	1.30m
5 adobe = 1.58m	1.60m	1.62m
6 adobe = 1.90m	1.92m	1.94m
7 adobe = 2.22m	2.24m	2.26m
8 adobe = 2.54m	2.56m	2.58m
9 adobe = 2.86m	2.88m	2.90m
10 adobe = 3.18m	3.20m	3.22m
11 adobe = 3.50m	3.52m	3.54m
12 adobe = 3.82m	3.84m	3.86m

"LA SEMILLA"

GROUND FLOOR SECOND ROW

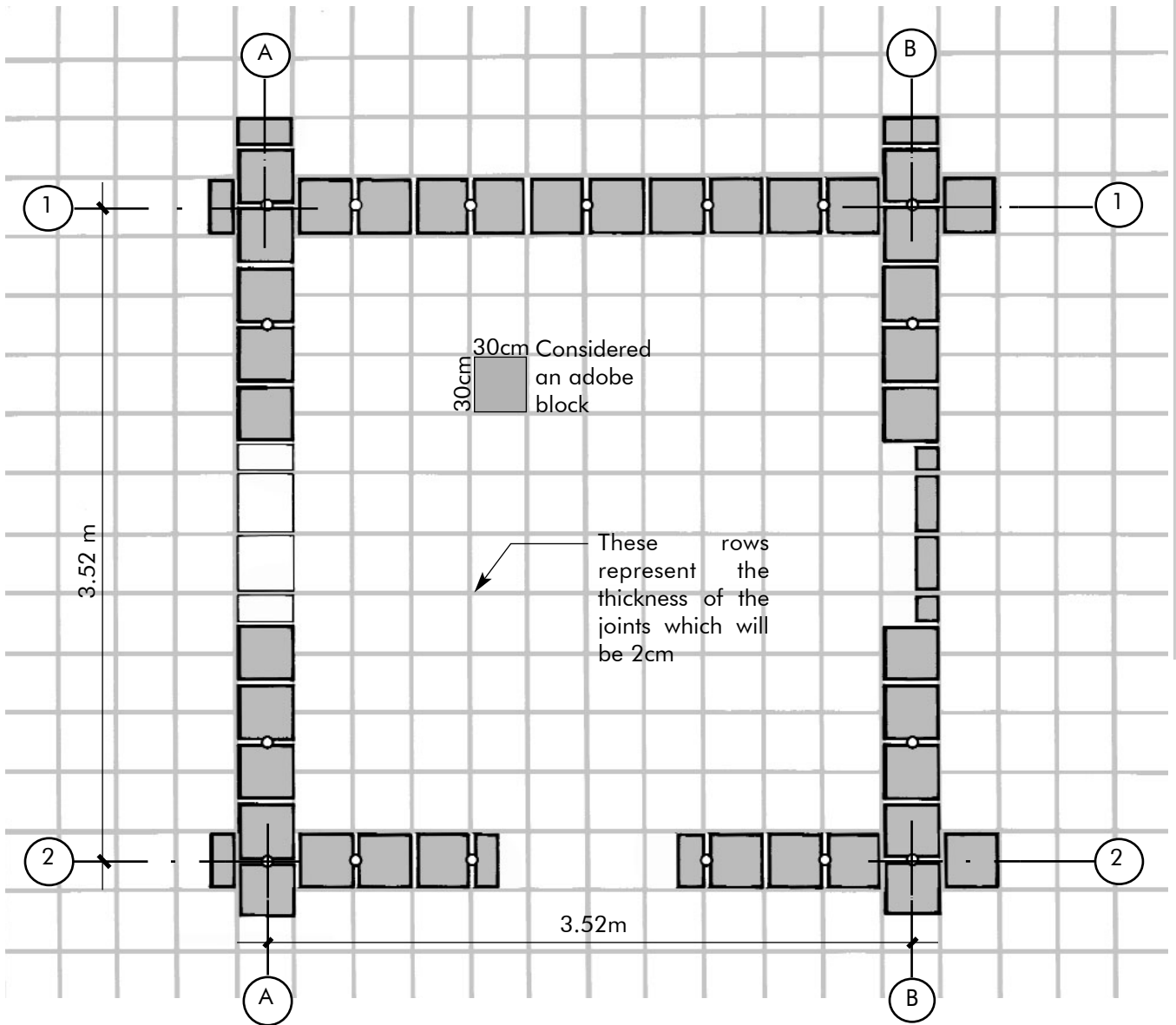
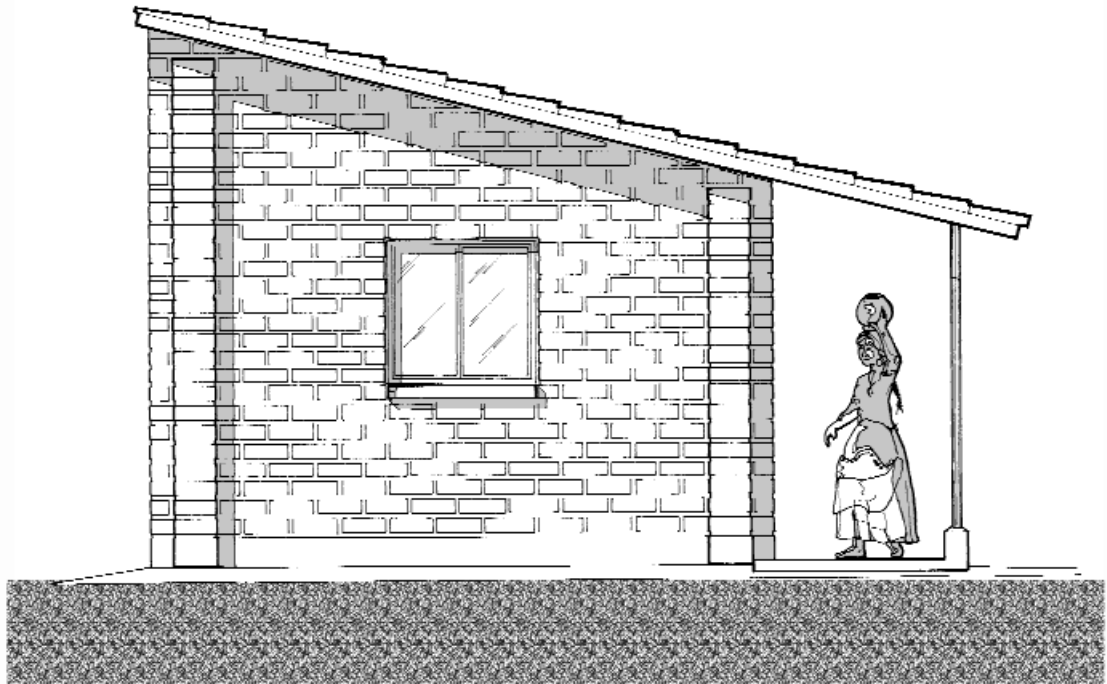


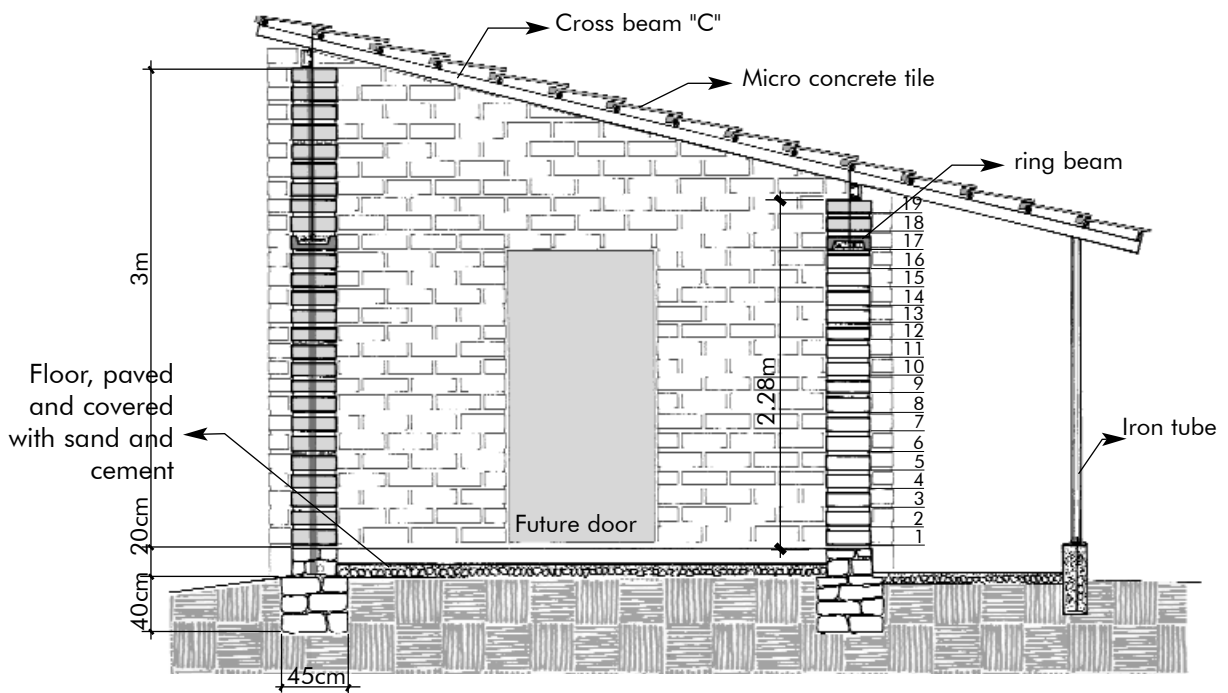
TABLE OF VERTICAL DISTANCES IN THE ADOBE WALL

1 adobe = 0.12m (adobe + joint)	13 adobe = 1.56m
2 adobe = 0.24m	14 adobe = 1.68m
3 adobe = 0.36m	15 adobe = 1.80m
4 adobe = 0.48m	16 adobe = 1.92m
5 adobe = 0.60m	17 adobe = 2.04m
6 adobe = 0.72m	18 adobe = 2.16m
7 adobe = 0.84m	19 adobe = 2.28m
8 adobe = 0.96m	20 adobe = 2.40m
9 adobe = 1.08m	21 adobe = 2.52m
10 adobe = 1.20m	22 adobe = 2.64m
11 adobe = 1.32m	23 adobe = 2.76m
12 adobe = 1.44m	24 adobe = 2.88m

ELEVATION & CROSS SECTION



LEFT LATERAL ELEVATION



CROSS SECTION A-A

FARMHOUSE WITH 20.74 M² LIVING SPACE

